# REFINER
## AND NATURAL GASOLINE MANUFACTURER

OCTOBER, 1940
Vol. 19, No. 10

*A Gulf Publishing Company Publication*
EDITED MONTHLY AT HOUSTON, TEXAS


*Copyright, 1940*


GRADY TRIPLETT
*Editor*


## CONTENTS


**Butyl Rubber—A New Hydrocarbon Product** ..... 47
R. M. Thomas, I. E. Lightbown, W. J. Sparks, P. K. Frolich and E. V. Murphree

**Waste Oil Receiver Automatic in Operation** ..... 58

**The Open Type Cooler** ..... 59
F. L. Kallam

**High Tensile Steel for Refinery Service** ..... 71
Weldon L. Archer

**Propane Treating With Caustic Solution** ..... 75

**Elements of Vaporization and Condensation (Part IX)** ..... 77
R. L. Huntington

**Surplus Gasoline Chief Flaw in Oil Picture** ..... 82
L. J. Logan

**Recycle of Stabilizer Bottoms** ..... 92


*Departments*


**Look Box** ..... 45 and 97

**Plant Activities** ..... 116

**Science and Technology** ..... 121

**New Equipment** ..... 128

**Business Notes** ..... 138

**Catalogs and Bulletins** ..... 144

**Advertisers' Index** ..... 146

SPECIALIZED OIL JOURNALS


*Published by*
THE GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *General Manager*
S. W. ROBINSON, *Editorial Director*
J. KENT RIDLEY, *Managing Editor*
TOM W. NELSON, *Advertising Manager*

NEW YORK: Room 625, 250 Park Avenue, Dick Swinsky, Manager.

PITTSBURGH: 72 Vandergrift Building, Chas. A. Wardley, Manager.

CHICAGO: 332 S. Michigan Avenue, H. G. Fitzpatrick, Manager.

LOS ANGELES: 425 W. W. Wilson Building, Huntington Park, California, Jay Curts, Jr., Manager.

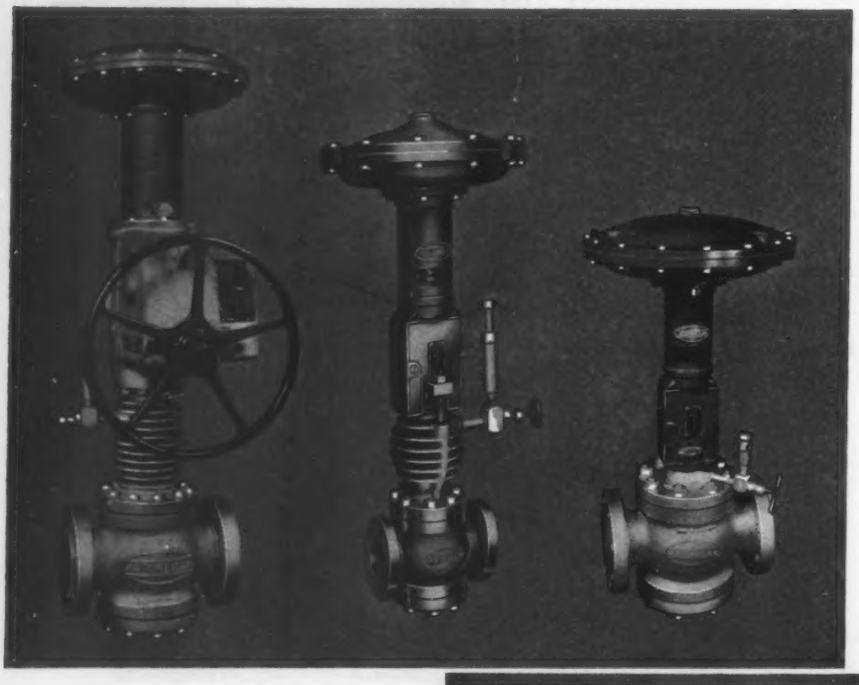
TULSA: 1304 Hunt Building, J. F. Carter, Jr., Manager.

FT. WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 20 cents. Special issues single copies 50 cents. Domestic subscription price $1.00 a year. Canada and Foreign subscription price $2.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Advertising rates on application.

Copyrighted 1940 by The Gulf Publishing Company.

# SPECIFY MASONEILAN CONTROL VALVES for ALL Refinery Requirements

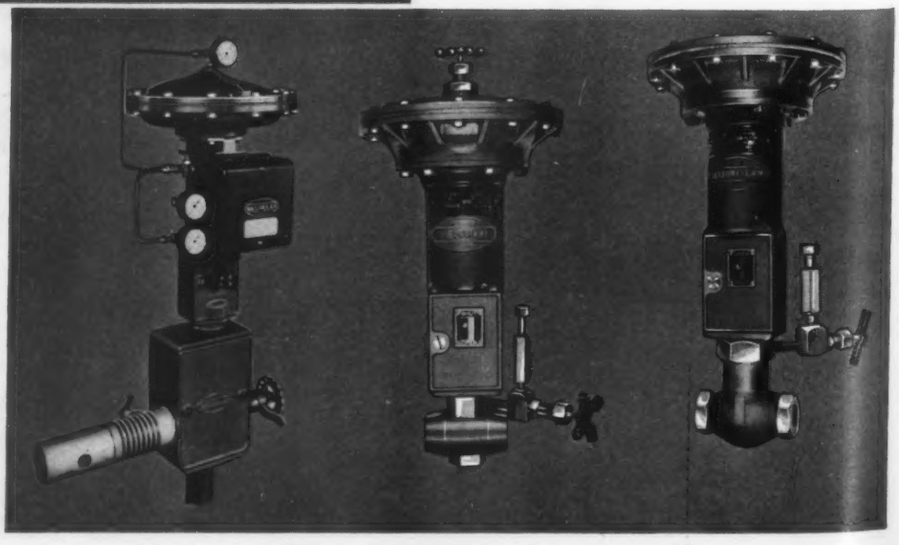


WHETHER it be for a pilot plant or a 10,000 barrel combination unit—in fact any refinery control job, from power plant to tank farm, there is a Masoneilan control valve specifically designed and built for your operating conditions. Each is a development of Masoneilan practical engineering based on years of close contact with your problems—each has the characteristics required on the job it is designed for—each is carefully built of the most suitable materials.

Thousands of Masoneilan Control Valves are demonstrating their superior performance, longer life and minimum maintenance costs every day wherever refineries and gasoline plants are built. Keep your units on stream longer and minimize your own headaches by specifying Masoneilan Control Valves for *all* refinery requirements. Data on any of the many available types, sent promptly on request.

**Standard Types** with or without air-fin bonnet, with or without the unique Masoneilan manual operating unit. Designed for the normal applications involving clean or semi-clean fluids, intermediate pressure drops and velocities.

**Pilot Plant Types,** handling drops instead of barrels at pressure drops from ounces to 6,000 lbs. With trim designed specifically for each individual application. These shown are a few of the many types that have been built.



VOLUME 19, No. 10 OCTOBER, 1940

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

# The Look Box

FOR all the spectacular promises of the defense program, the domestic market is still the source to which the refining industry must look for its profits. Unless it gears its operations to the demands of gasoline and distillate, there is little prospect of profit from the special products, which military needs offer.

## Domestic Demand Still Foremost

The immediate question before the industry is what to do about the furnace distillate season, the period from October 1 to April 1. For several years the industry failed to provide sufficient stocks to meet the abnormal increases in distillate consumption. This seems to have changed for the present and the refiner who goes into distillate production in anticipation of trends similar to recent winter seasons will be bucking a larger inventory.

At the end of March, 1940, the industry had distillate stocks of 23,500,000 barrels, 9,500,000 barrels in California and 14,000,000 east of the Rocky Mountains. September 30, however, this had increased to total distillate stocks of 48,000,000 barrels, with 37,000,000 barrels east of the Rocky Mountains. The gasoline consuming season of 1940 had put 24,500,000 barrels of furnace distillate in tanks and 23,000,000 barrels of this had been added in the eastern part of the United States.

By comparison with September 30, 1939, the industry has increased its distillate stocks by 10,000,000 barrels and practically all of this material is east of California. The increase is almost 30 percent above last year. In terms of the winter demand, both domestic and foreign, the stocks are almost 10 percent higher than the previous year. This means that the industry could meet an increase of 10 percent in distillate requirements simply by maintaining its output of this product at the rate of last winter.

By continuing the high percentage of distillate recovery that has prevailed this year, a percentage that should be increased to 15 percent of crude charge, the industry could satisfy the distillate demand at a lower total refinery throughput. Various authorities estimate that not more than 3,400,000 barrels of oil should be charged daily during the winter. East of California total throughput should be no higher than 2,900,000 barrels. This rate of operation with 15 percent of the total converted into distillate should provide adequate light fuel oils in the light of the increase in stocks from the summer gasoline season.

This level of refinery operation is 200,000 barrels lower than the throughput of September. Since California operates at around 500,000 barrels daily the reduction should be in the remaining refining centers.

Another fact to support curtailment is the gasoline stock situation, now 82,000,000 barrels, 11,-

000,000 barrels higher than last year. If the industrp is to get its gasoline house in order it can not afford to accumulate heavy supplies during the winter. Daily throughput of not more than 3,400,000 barrels should result in no more than 7,000,000 barrels of gasoline going into storage prior to April 1, 1941.

This is the statistical situation, something each executive should study as he fixes policy for plant operation during the winter.

## Oil for the Voting Machine

ONLY in its political applications does the anti-trust suit against the petroleum industry make sense. Although the plea to the public is without logic, it may appeal to voters. Thus an administration, whose drive toward national defense is painted as little short of holy, stoops to the doubtful position of hampering an industry in the hope that the act will be accepted by a worshiping public.

For instance, in his statement to the public the attorney general said that success for the litigation would bring the following conflicting benefits:

"Independent producers should receive higher prices for their crude oil and independent refiners should be able to compete with the major oil companies. With competition restored to the oil industry, gasoline, fuel oils, kerosene and lubricants should be sold at lower prices to the consumer, who should then receive the benefits of technological improvements and the opportunity to purchase a variety of products."

It would be fortunate if the government would strive to maintain that position in court. Even a friendly court might find it difficult to understand how a higher price could be paid for raw material and a lower price accepted for the finished product. The position does not have logic. It does, however, fit into the trend at Washington, which has for seven years been assuring a public that the way to have more is to produce less.

That part of the statement is for the public. The plea to the court will be on other grounds. One of these is that the industry is without competition. Evidently this implies that gasoline goes to the public at fixed prices.

Recently, this writer completed more than 5000 miles of driving in 19 states. From 32 sales records in hand, the record shows that the price of gasoline varies from 15½ cents to 25 cents a gallon, a range far too wide to be accounted for in the difference in tax and transportation. If there is collusion in price fixing, it ceases to exist at the pump, which is where the public meets the oil industry.

Another plea for the court will be that the industry has failed to give the public the benefit of technological development. But gasoline is one product whose retail price has gone downward steadily over the last 20 years, the period in which the industry has made its technological development. That, plus the lower cost of raw material, has permitted the decreasing price, despite increasing taxes.

Most glaring of the inconsistencies of the suit is the contention that restrictions on crude oil production and the manufacture of finished material has been "accomplished in part through a system of reports to the American Petroleum Institute, covering the amounts and locations of all stocks of petroleum products owned or held by each of the defendants."

Dissolution of the American Petroleum Institute is sought because of this charge.

Why the industry would set up an organization for this purpose is beyond reason. Through the government itself, the industry has figures, which are offered as recommendations of current oil field production. The Department of Justice should consult the Department of Interior, whose Bureau of Mines, not only publishes figures but recommends rates of production for each state. It is upon these that state conservation authorities are asked to base orders of proration.

The whole petition is so filled with inconsistencies that under conditions of fair play and straight thinking the industry could afford to laugh as it prepares its defense. But the government of the United States is not one of logic or fair play. On that account the anti-trust litigation is nothing to be taken lightly. Controlled courts and an administration bent on perpetuating itself are a combination that defy proof and logic.

The suit is being offered in a form not to interfere with national defense, since divorcement of pipe lines is not being sought. Instead, three suits against pipe-line control by three integrated concerns will be instituted at different points.

What the litigation will do to national defense remains to be seen. It seems reasonable, however, that whatever time executives are required to spend on the witness stand will be time away from directing the output of materials the national defense program demands.

The pitiful prospect is that a public, which trusts rather than reasons, will hail the move as the signal for cheaper gasoline. Whether independent oil producers will be gullible enough to accept higher crude oil prices and lower gasoline prices from the suit is doubtful. Meanwhile, the man who is in business may not consider his activity a crime, but he well may wonder if it is not a foolish adventure.

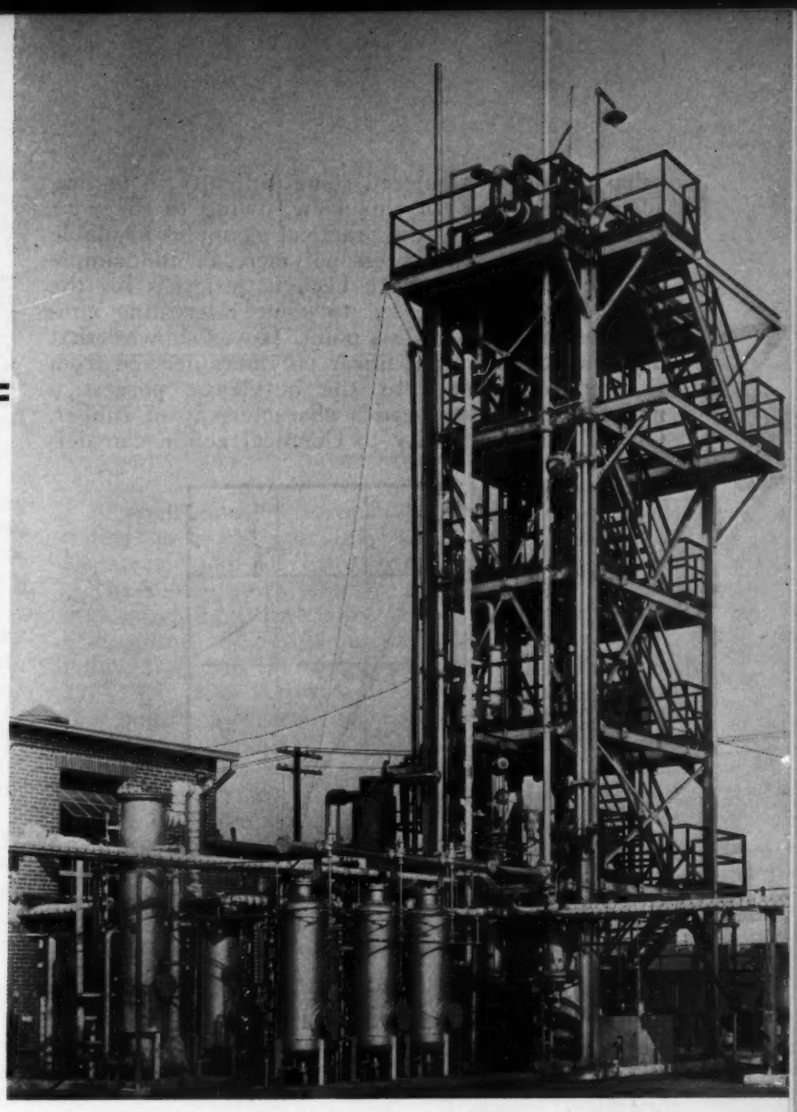
Just as the individual is cautioned about having his cake and eating it, government may come to the day when it realizes that it can not have an industry which has been devoured.

**THIS paper presents the results of a thoroughly unorthodox approach to the synthetic rubber problem. In developing their new butyl rubber, Esso Laboratories have turned to simple olefins rather than diolefins or more complicated chemical derivatives as the main raw material. Not only is this an economic advantage, but the ready availability of such simple olefins from refinery cracking operations makes the process seem attractive from the standpoint of potential supply of synthetic rubber.**

**As only the limited amount of unsaturation required for curing with sulfur has been provided, the vulcanizates are substantially saturated and therefore possess the chemical stability characteristic of a paraffin hydrocarbon. In spite of this radical difference in internal structure, the polymer can be processed in much the same manner as natural rubber, and the physical properties of natural rubber have been retained to a surprising extent. Because of the low degree of unsaturation and consequent chemical inertness, the available information indicates that butyl rubber will be superior to natural rubber for many purposes.**

**This paper was part of the program of the annual meeting of the American Chemical Society in Detroit, September 9 to 13, 1940. It is offered through the courtesy of Industrial and Engineering Chemistry, October, 1940.**

**At right is a view of a semi-commercial butyl rubber plant.**



# Butyl Rubber
## A New Hydrocarbon Product

R. M. THOMAS, I. E. LIGHTBOWN, W. J. SPARKS, P. K. FROLICH, and E. V. MURPHREE
Esso Laboratories,
Standard Oil Development Company,
Elizabeth, New Jersey

THE present distinction between the thoughts expressed by the terms "synthetic rubber" and "rubber synthesis" are indicative of the changes in viewpoint upon which current progress in the duplication of rubber-like properties is based. For almost 50 years after the discovery by Williams[32] that isoprene is the fundamental structural unit of rubber, research was directed toward rubber synthesis. Bouchardat[2], Tilden[27], Wallach[28], Hoffman[12], Matthews[16], and Harries[10] all made valuable contributions to the chemistry of rubber-like products from isoprene. That none of them accomplished the purpose of synthesizing rubber is an accepted fact.

In the preparation of a rubber-like material from dimethylbutadiene, Kondakow[14] departed from classical attempts at rubber synthesis and laid the foundation for the first commercial "synthetic rubber,"[8] the German wartime "methyl rubber."

The tradition that rubber properties were related to high unsaturation persisted and has led to numerous theories[7, 11, 15] of elastic behavior based on geometric structures resulting from unsaturated linkages. Whitby[30] and Staudinger[25] questioned the importance of unsaturation in determining rubber-like

behavior but encountered some difficulty in finding adequate support for this view, owing to the poor elastic properties of the practical examples available to them. Our studies on polymers of the simple mono-olefins, which have been in progress for the past ten years, have led to some interesting conclusions in regard to this point. It was shown[21] that high-molecular-weight linear polymers derived from simple olefins, such as the butylenes, possess a majority of the properties characteristic of rubber. Only the susceptibility to chemical action can def-

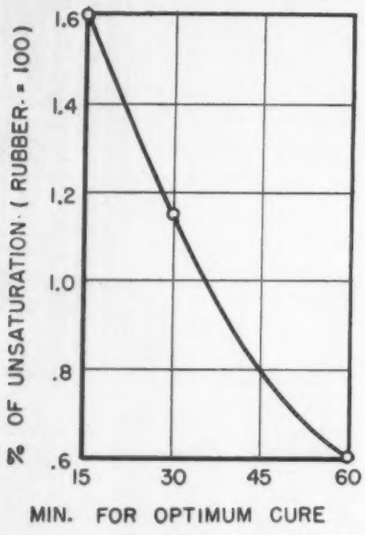



**FIGURE 1**
**Effect of Unsaturation of Butyl A on Rate of Cure at 150° C. (311° F.)**

initely be attributed to the unsaturation of the natural rubber molecule. Physical properties which appear not to be intrinsically dependent upon the carbon-double bond-carbon configuration are: tensile strength, elasticity, rebound, elastic memory, x-ray structure, mechanical orientation, electrical properties, and fractional solubility. It was, however, conclusively demonstrated that the saturated polymers are not capable of vulcanization in conventional manner.

From these and other studies it is concluded that the chemical unsaturation, which is so important from the standpoint of permitting vulcanization to take place, is also the greatest weakness of the natural rubber molecule. The reason for this is that in the case of soft goods, which represent by far the major outlet for rubber, only a fraction of the available double bonds is utilized in the vulcanization with sulfur. The low but definite consumption of unsaturation during vulcanization of rubber was first pointed out in 1912 by Spence and Scott[22]. Their conclusions were further confirmed by Boggs and Blake[1] and by Brown and Hauser.[3] The latter showed that there is evidence of overcuring after as little as 2 to 3 percent of the unsaturation has been used up. The large residual unsaturation is responsible for the pronounced chemical reactivity of soft rubber goods. It is this unsaturated character which makes natural rubber so susceptible to oxidation with consequent deterioration on aging and disintegration when subjected to the action of ozone. It is also responsible for its lack of resistance to such chemical agents as strong mineral acids, and also to its lack of heat stability under oxidizing conditions.

**TABLE I**
**Effect of Accelerators on Vulcanization of Butyl Rubber**

| Accelerator | Condition of Cure |
|---|---|
| Tetramethylthiuram disulfide | Good |
| Zinc dibutyl dithiocarbamate | Good |
| Butyraldehyde-aniline | Poor, blistered |
| Piperidinium pentamethylene dithiocarbamate | Poor |
| Thiocarbanilide | Poor |
| Benzothiazyl disulfide + diphenylguanidine | Poor |
| Mercaptobenzothiazole (Captax) + tetramethylthiuram disulfide (Tuads) | Good |

We are therefore confronted with a property of natural rubber on which it should be possible to effect a major improvement by synthetic methods.

## General Description of Butyl Rubber

With the foregoing considerations in mind, we approached the problem of producing a polymeric material having only the limited amount of unsaturation required for vulcanization — but no more. Upon completion of the curing operation, such a product should give a rubber with substantially no unsaturation and therefore with the chemical stability characteristic of a saturated paraffin hydrocarbon.

Researches undertaken to this end in the Esso Laboratories have led to the development of butyl rubber, which is a co-polymer of olefins with small amounts of diolefins. This program has been carried through entirely independent of any other synthetic rubber development either in this country or abroad.

The technique employed in this polymerization can best be made the subject of separate discussions. However, anyone familiar with hydrocarbon chemistry will appreciate the economic advantage of being able to utilize largely a simple olefin rather than a diolefin as the raw material in this synthetic rubber process.

The designation "butyl rubber" must be considered a generic term, for by varying the olefinic and diolefinic materials employed, it has been found possible to obtain products that differ considerably in their detailed properties, even though the basic characteristic remains the same in so far as the limited unsaturation is concerned.

In the discussion which follows, however, the name will be used less broadly to describe a 100 percent petroleum hydrocarbon product with an unsaturation corresponding to between 1 and 2 percent of that found in natural rubber, as determined by iodine number, and with a molecular weight in the general range of 40,000 to 80,000 as determined by viscosity measurements on dilute solutions. Because of its freedom from impurities, in so far as these can be detected by ordinary chemical analysis, it is colorless and devoid of odor or taste. In appearance it resembles natural crepe rubber. Since it is an aliphatic hydrocarbon polymer, the density (0.91) approaches the minimum attainable for elastic materials of this type.

Because the original unsaturation is very small, and because even this low unsaturation is greatly reduced (and may even be entirely eliminated) during the curing operation, vulcanized butyl rubber is extremely resistant to chemical attack. This is true because it has become, after vulcanization, not only a nonthermoplastic, strong elastic material, but also an essentially chemically saturated product as well. This means that, while from a physical standpoint vulcanized butyl rubber resembles soft vulcanized natural rubber, chemically it may be considered more

similar to ebonite. It is extremely resistant to acids (even concentrated sulfuric or nitric), to oxidation, to ozone, and to other deteriorating influences. Like natural rubber, butyl rubber is not resistant to aliphatic hydrocarbons, but it does show a surprising resistance to benzene, ethylene dichloride, and oxygenated solvents.

### Vulcanization

In accordance with modern ideas of functionality and the fact that saturated polymers do not vulcanize by conventional methods[4], it is evident that vulcanizability is not independent of unsaturation. This principle is illustrated by Figure 1 which shows the effect of double bonds on the rate of vulcanization of butyl rubber varieties of varying unsaturation, using typical polymers and a standard compounding formula.

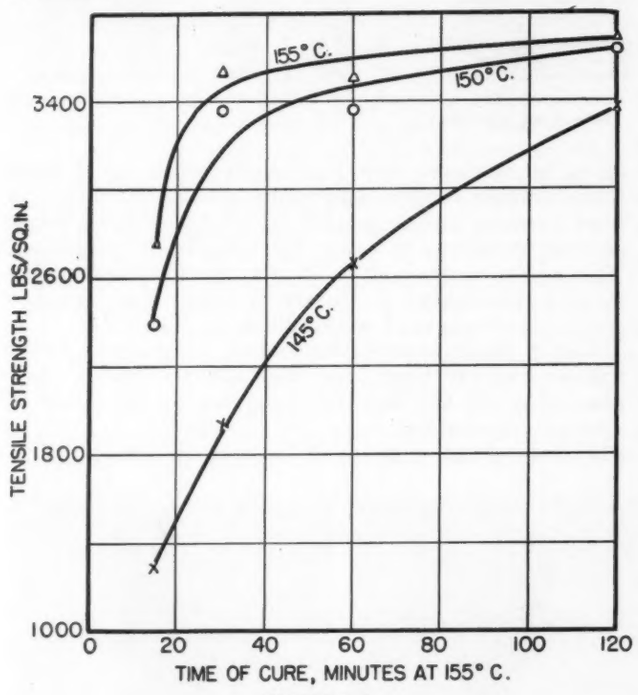



**FIGURE 2**

**Effect of Temperature on the Curing Rate of Butyl A.**

However, it will be appreciated that rate of vulcanization is not the only criterion of vulcanizability, and that the time to reach optimum cure as evidenced by tensile strength may bear little relation to practical problems of utilization. Modern views of polymerization phenomena[4] indicate that the functionality per molecule as well as percentage of functional groups on a weight basis is important. This is qualitatively true for vulcanization of butyl rubber. The addition of certain foreign unsaturated materials having functionality toward sulfur produces unfavorable results. For example, small amounts of oleic acid, dipentene, and even rubber itself have interfered with curing in various instances. On the other hand, butyl rubber appears to be without effect when added in small percentages to rubber.

The choice of accelerators is also an important problem in butyl rubber compounding. The resemblance to rubber in this respect is limited to the fact that certain accelerators for rubber can be used. The data in Table I illustrate the behavior of some common rubber accelerators when used in a particular butyl rubber stock.

**TABLE II**

**Effect of Temperature on Curing Rate of Butyl Rubber**

| | 138° C. (280° F.) Cure | | 145° C. (293° F.) Cure | | 150° C. (302° F.) Cure | | 155° C. (311° F.) Cure | |
|---|---|---|---|---|---|---|---|---|
| Cure, Min. | Tensile Strength Lb./sq. in. | Elongation Per-cent | Tensile Strength Lb./sq. in. | Elongation Per-cent | Tensile Strength Lb./sq. in. | Elongation Per-cent | Tensile Strength Lb./sq. in. | Elongation Per-cent |
| 15..... | Under-cured | .... | 1300 | 1270 | 2400 | 1130 | 2780 | 1070 |
| 30..... | 1400 | 1260 | 1970 | 1080 | 3350 | 1090 | 3540 | 1000 |
| 60..... | 2720 | 1180 | 2640 | 1000 | 3360 | 970 | 3510 | 980 |
| 120..... | 2930 | 1030 | 3360 | 980 | 3620 | 980 | 3640 | 970 |

A representative formula for butyl rubber compounds is as follows: butyl rubber 100.0, zinc oxide 5.0, stearic acid 3.0, sulfur 3.0, Tuads 1.0.

The temperature effective in curing butyl rubber into which have been compounded zinc oxide, stearic acid, sulfur, and accelerator is from a practical standpoint largely in the range between 140° and 200° C. (284° and 392° F.). Most of the results reported in this paper have been obtained when working with a curing temperature of 155° C. (311° F.). At this temperature the curing rate of the butyl rubber stock used for the data presented in Table II and Figure 2 is comparable with that of natural rubber which is being cured with, say, a guanidine or with a mercaptothiazole.

No tendency to overcure is encountered in increasing the time from 1 to 2 hours in the 155° C. test. This observation is, of course, true for this particular type of butyl rubber, whereas other types may definitely overcure under even milder conditions.

### Resistance to Aging and Other Chemical Action

Dufraisse[5] summarized his views on the oxidative character of rubber as follows: "It would be difficult to understand its behavior in air if one were to lose sight of the fact that its chemical structure makes it an essentially autoxidizable substance. Often dormant, its reactivity is always ready to be awakened at the first provocation."

The enormous literature on rubber aging cannot be summarized here. It is, however, a widely observed fact that two types of rubber deterioration occur—namely, tackiness and hardening. These different phenomena are summarized from Staudinger's work[24] as follows: "Every reaction which shortens the length of molecules liquefies the mass; and, conversely, every reaction which lengthens the atomic chains tends to solidify the mass. These two actions correspond exactly to the chief transformations which rubber undergoes, which are nothing more than changes in consistency—viz., a fluidifying degradation and a hardening."

Butyl rubber offers an opportunity of generically separating these phenomena. Butyl rubber varieties of low unsaturation undergo only the degradative or or softening type of deterioration under the severe influence of heat, light, and air. Since natural rubber predominantly undergoes hardening deterioration, this behavior must be due to unsaturation, and the action of butyl rubber confirms the following conclusion of Dufraisse[6]: "Olefins are particularly subject to this change (autoxidation) because of the tendency of the double linkage to become saturated by condensation; this is also the case with substances having relatively large molecules, such as drving oils as well as the simple derivatives of ethylene."

By elimination of excessive unsaturation, the major

cause of rubber deterioration has been removed. In general, the use of age resisters is unnecessary since butyl rubber vulcanizates may be even more resistant to age deterioration than natural rubber containing the best antioxidants. If age resisters, such as phenyl β-naphthylamine, are used in butyl rubber of the lowest unsaturation, the results are found to be somewhat erratic, sometimes showing the addition of age resisters to be of benefit, sometimes of no benefit. In any event, the fortification of butyl rubber by age resisters is not relatively so great as in natural rubber, nor is it so important. This also means that age-resister staining is not a problem with butyl rubber.

Laboratory aging tests have been conducted in a standard Bierer-Davis rubber aging bomb at a constant temperature of 70° C. (158° F.), and an oxygen pressure of 300 pounds per square inch. The time of aging is 14 days. This prolonged bomb aging time (considerably longer than that for natural rubber) is used because aging periods of 48, 72, and 96 hours are not sufficient to cause measurable deterioration. The age resistance of a 50 percent Calcene loaded stock is illustrated in Figure 3. Other butyl rubber stocks are compared with rubber in Table III.

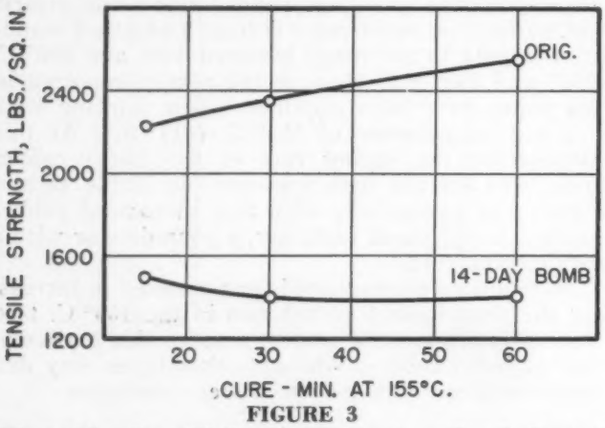


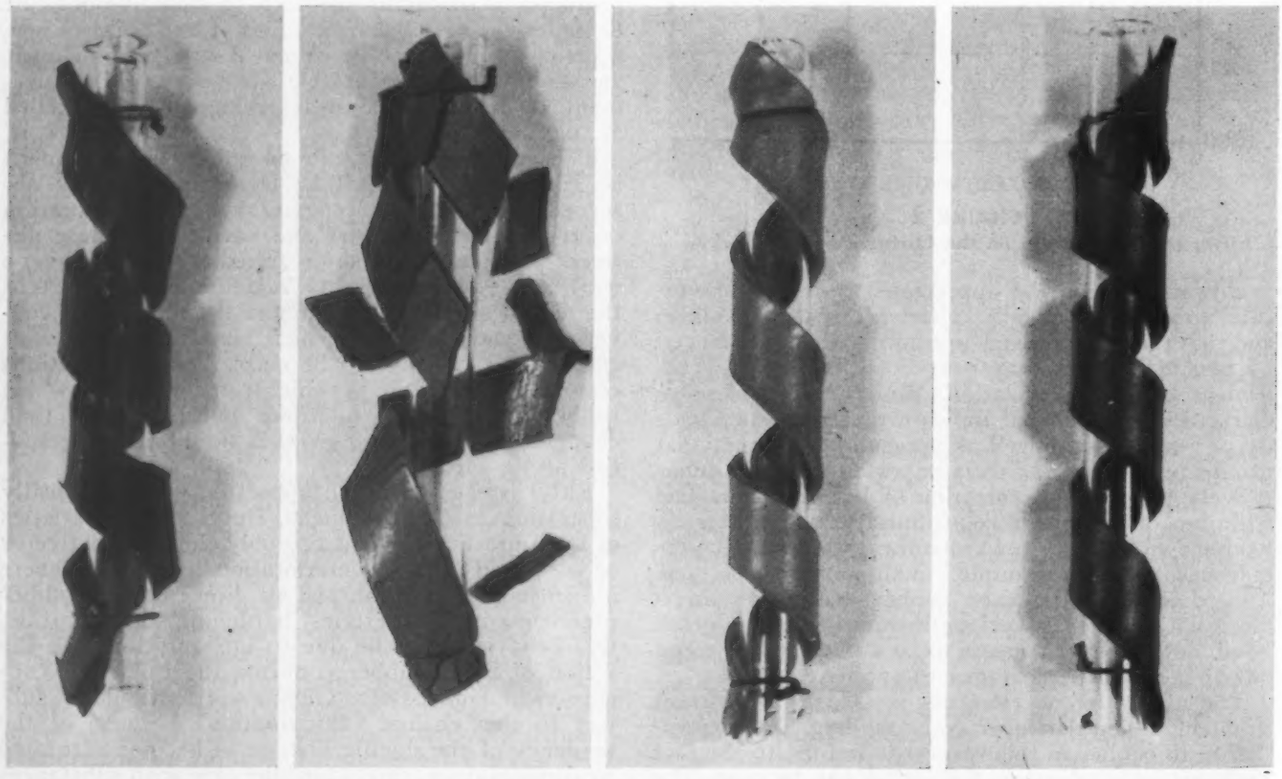

**FIGURE 3**
**Effect of Loading (50 Per Cent Calcene) on Tensile Strength of Butyl A.**

**TABLE III**
**Heat and Age Stability of Rubber and Butyl Rubber in Geer Oven**

| Loading (on Total Gum) | Tensile Strength, Lb./Sq. In. Original | 14 Days, 70° C. Oven | 7 Days, 100° C. Oven | 24 Hr., 150° C. Oven |
|---|---|---|---|---|
| **NATURAL RUBBER** | | | | |
| No. 1 pure gum | 3400 | 2500 | 0 (brittle) | Melt |
| No. 2 pure gum (heat-resistant) | 2700 | 2780 | 0 (brittle) | Melt |
| **BUTYL RUBBER** | | | | |
| Pure Gum | 3500 | 3500 | 2870 | Melt |
| 85 percent Calcene | 2300 | 2320 | 1800 | Melt |
| 50 percent Gastex | 2600 | 2300 | 2300 | 660 |
| 85 percent Gastex | 2000 | 1800 | 1800 | 670 |
| 50 percent gas black* | 3300 | 3000 | 2720 | 920 |
| 85 percent gas black* | 2600 | 2260 | 2180 | 1330 |
| 50 percent Zinc oxide | 3340 | 2850 | 2040 | Melt |
| 85 percent Zinc oxide | 3100 | 3000 | 2350 | Melt |
| 50 percent P-33 | 3000 | 2560 | 2000 | 440 |
| 85 percent P-33 | 2300 | 2000 | 1870 | 620 |
| 50 percent lithopone | 3300 | 3150 | 2300 | Melt |
| 85 percent lithopone | 3000 | 2560 | 1870 | Melt |

* Cabot No. 9 gas black.

While these results show that, in general, butyl rubber has excellent heat and age resistance, they also bring out the fact that, whereas the elevation in aging temperature from 70° to 100° C. (158° to 212° F.) makes a great difference in the physical



Natural rubber carbon black loading, 4-min. exposure | Natural rubber, pure gum, 4-min. exposure | Butyl rubber, pure gum, 1.5-hr. exposure | Butyl rubber, carbon black loading, 1.5-hr. exposure

**FIGURE 4**
**Resistance of Samples Exposed to Ozonized Air (0.22 Percent Ozone)**

properties of natural rubber, it makes relatively little difference in the physical properties of butyl rubber.

Specifically, if pure gum butyl rubber is compared with a pure gum heat-resisting natural rubber, it will be seen that from 2 weeks at 70° C. the tensile strength of neither stock has been decreased. But elevating the temperature to 100° C. ruins the natural rubber while the butyl rubber still retains most of its original tensile strength.

Similarly, in sunlight only the depolymerization behavior of rubber is exhibited by butyl rubber. Where objectionable, this tendency can be overcome by loading with carbon black to the extent of some 30 percent or more. Such samples have been found to have cracked less after 4 months of direct summer sunlight than are natural rubber tire tread samples exposed similarly for only a week.

The catalytic aging effect of certain metals has also received wide attention[17, 26]. As Table IV shows, butyl rubber, which has been mixed with copper, manganese, or cobalt salts, has approximately the same tensile strength after aging as before; rubber treated in the same way is completely deteriorated.

As a comparison, 0.5 percent manganese phenol sulfide and 0.5 percent copper oleate were milled into natural rubber. After 14 hours (in comparison with 7 days for butyl rubber) in the Geer oven at 95° C. the tensile strength was so low it could not be determined. In another experiment 1 percent cobalt phenol sulfide was added to a natural rubber composition, and the vulcanizate was aged in the Bierer bomb for 72 hours. At the end of this aging period the rubber sample had melted and fallen to the bottom of the bomb. It is apparent that the acceleration of aging by metallic catalysts is related to the presence of an excessive amount of unsaturation in the rubber molecule.

That attack by ozone is characteristic of high unsaturation in the rubber molecule has been adequately demonstrated by Harries[9]. In accordance with Staudinger's view[24] that only a very few scissions of large molecules will produce marked evidence of degradation, it is apparent that even polymers of low residual unsaturation would be vulnerable to ozone attack. Butyl rubber varieties of varying ozone resistance have been prepared. Most varieties are remarkably stable to strong ozone. This characteristic is illustrated in Figure 4.

Another of butyl rubber's salient characteristics, which is again related to its chemically saturated nature, is its unusual acid resistance. So far as we know it is unique in this respect, since it is the only acid-resisting plastic that is vulcanizable. When soft vulcanized natural rubber is immersed in concentrated sulfuric acid or nitric acid, its useful life is ended within a few hours or even minutes. Under identical conditions, pure-gum butyl rubber vulcanizates have been observed to last several months. Figures 5 and 6 compare butyl rubber and natural rubber in their resistance to concentrated sulfuric and nitric acids.

## Processing

A relation between the processing properties of rubber and its viscosity in solution was suggested by Schidrowitz and Goldsborough in 1909[19]. This property was later translated into a measure of molecular weight by Staudinger[23]. It is reasonable to expect that, aside from differences in types of butyl rubber products, a variation in processing dependent upon molecular weight is also possible. In general, however, the processing of butyl rubber is not essentially different from that of natural rubber except that it needs no breakdown or mastication but is ready for the incorporation of pigment or vulcanizing ingredients as soon as it has formed a continuous sheet around the mill roll. In the unvulcanized state the material exhibits a peculiar thermoplastic property which seems to be modified at high temperatures. This can be noted by thermal characteristics on the mill. When first placed on the mill rolls while cold, butyl rubber is tough and ropy. As soon as it is warmed by internal friction to 80-100° C. (176-212° F.), it becomes soft and smooth; if it is heated above this temperature, it becomes crumbly again, in this respect exhibiting a kind of thermoplastic reversion.

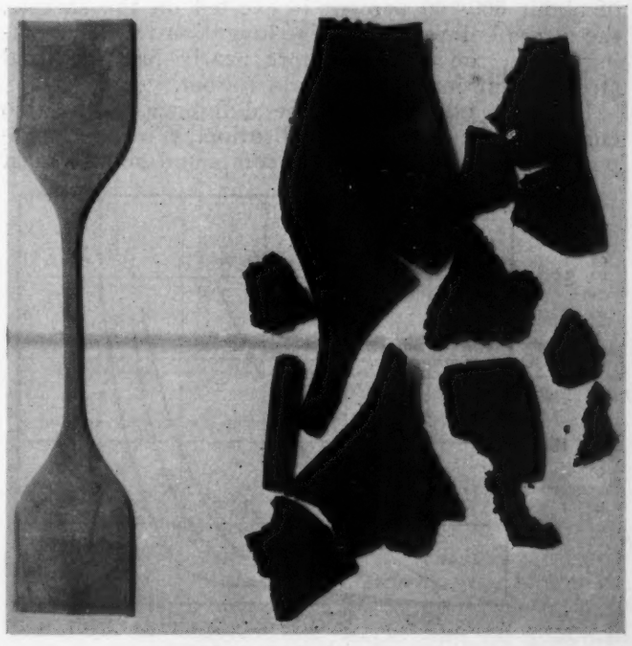
**TABLE IV**
**Effect of Metallic Salts on Deterioration of Butyl Rubber by Oxygen**

| Sample No. | Percent Metal Salt Added | Type of Aging | Tensile Strength, Lb./Sq. In. | | Elongation, Percent | |
|---|---|---|---|---|---|---|
| | | | Original | After Aging | Original | After Aging |
| 461 | ..... | 7 days, Geer oven, 95° C. (203° F.) | 2110 | 1880 | 1000 | 1000 |
| 470-A | 1 Cu oleate | Same | 2070 | 2380 | 1000 | 1000 |
| 473 | 0.5 Mn phenol sulfide | Same | 2250 | 2000 | 950 | 1020 |
| | Same | 92 hr., Bierer bomb, 70° C. (158° F.) | 2250 | 2140 | 1050 | 1070 |

## Tensile Strength

From a practical standpoint the relation between tensile strength and commercial utilization is obscure. However, in laboratory evaluation, tensile strength offers a ready means of classification of products and has been used as a standard for much of our work. For theoretical considerations, tensile product or preferably tensile strength calculated from cross section at break may be more significant.

Table I shows that strengths of 3600 pounds and



Butyl Rubber Natural Rubber

**FIGURE 5**
**Relative Resistance of Butyl Rubber and Natural Rubber to Concentrated Sulfuric Acid After 10-Day Immersion.**

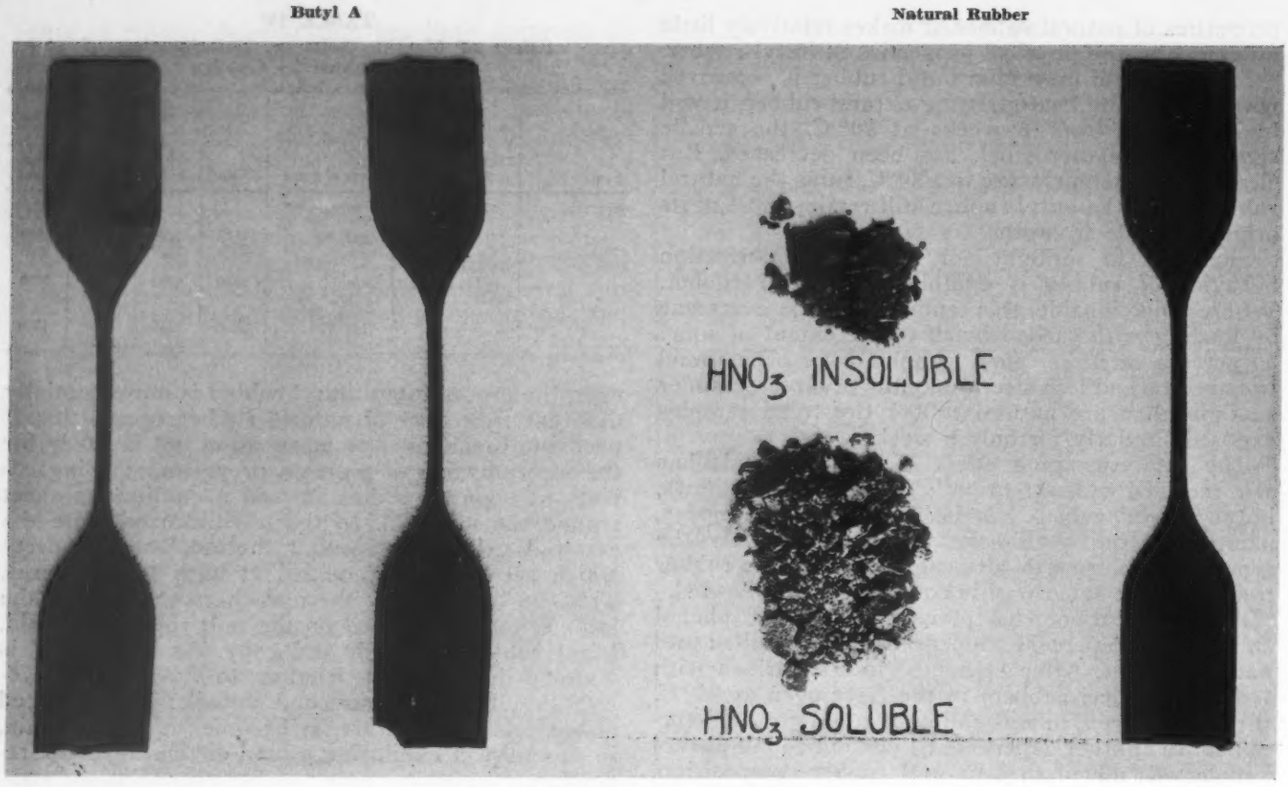



**FIGURE 6**

**Relative Resistance of Butyl Rubber and Natural Rubber to Concentrated Nitric Acid**

elongations of 1000 percent are readily obtainable. Calculated on the basis of cross section at break, this gives actual strength figures greatly in excess of those of natural rubber.

### Stress-Strain Relation

The stress-strain curve in butyl rubber is different from that of natural rubber (Figure 7). Until a strain of about 500-700 percent is exerted on the sample, the stress is low; from this elongation to the breaking point, the curve is more nearly like the total stress-strain curve for natural rubber.

It is not certain what the difference in the two curves means in actual application. Wiegand[21] proposed that the ideal rubber compound should most nearly obey Hooke's law—i. e., give a straight-line relation. In discussing this, Shepard, Street, and Sharp[20] suggested an opposite viewpoint: "It may be that one of the most valuable properties of rubber in abrasive service is its low rigidity which allows it to back away from the impact point without rupture." This is, in fact the case, as measured by shock cutting resistance of rubber and butyl rubber loaded with carbon black to similar hardness and flexing characteristics as described below.

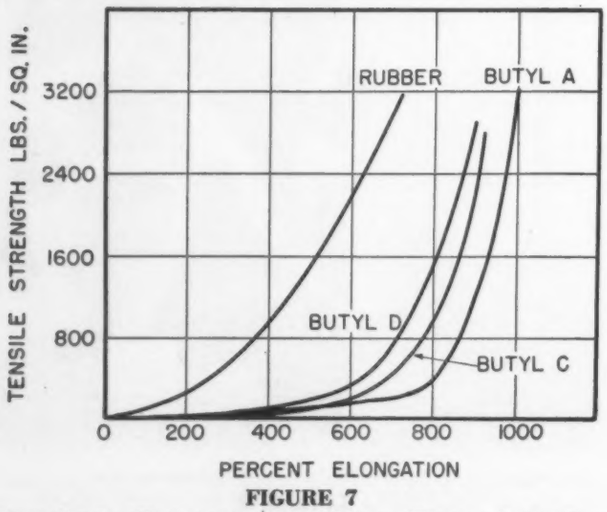



**FIGURE 7**

**Stress-Strain Characteristics of Three Types of Butyl as Compared With Natural Rubber.**

### Impact Cutting Resistance

This test is based on a simple method used in our laboratories. A flat, rigidly held, horizontal steel plate supports the specimen under test, a block ¾ × ¾ × ⅓ inch thick. To another flat steel plate, weighing 30 pounds and parallel with the base plate, a triangular file is attached by means of a halter. This upper plate is dropped from a height of 6 inches directly on the rubber block so that the full impact is concentrated on the specimen along the file edge. The test can be fairly accurately duplicated, in that similar samples are cut to the same degree.

The conclusions drawn from the results of this test are:

1. Butyl rubber containing 80 percent Gastex or gas black has considerably better shock resistance than a natural rubber compound of the same hardness, containing about 50 percent gas black.
2. Increase in loading improves the shock resistance.
3. There is no quantitative relation between shock resistance and abrasion resistance as measured by laboratory methods, although in general, highly loaded stocks have both good abrasion and shock resistance.

### Loading and Reinforcing

Up to this point we have considered primarily butyl rubber mixtures without fillers, although in

practice compounding ingredients are usually added. Butyl rubber may be compounded with most of the ordinary pigments used in natural rubber, but a description of the influence of all such ingredients would lead too far afield. From the standpoint of tensile strength, butyl rubber differs from rubber in that carbon blacks of the reinforcing type do not increase the tensile strength except for certain rapid-curing

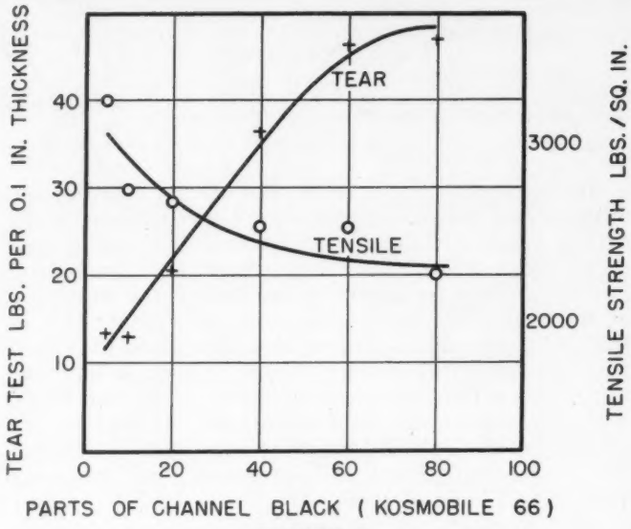



**FIGURE 8**
**Crescent Tear Test on Butyl A**

stocks, and the change in tensile strength with carbon black and with other pigments is not greatly different for the various inert fillers. This is illustrated in Figures 8 and 9 for channel gas black and for titanium dioxide.

Carbon black is an important pigment for butyl rubber, as it is also for natural rubber. The synthetic polymer may be much more heavily loaded with carbon black without becoming excessively hard and stiff and without readily cracking under constant flexure. Amounts as high as 100 parts of carbon black per 100 parts of butyl rubber can be readily incorporated without the flex-cracking problem becoming any more acute than it is with a natural rubber compound containing 50 percent black on the weight of the gum, or without the polymer compound hardness exceeding about 65° Shore.

As stated above, tensile strength of butyl rubber is not generally increased to any great extent by the addition of carbon black. Other manifestations of reinforcement are, however, present. Thus, the abrasion resistance (as determined by laboratory test methods), the cutting resistance, the shock resistance, and the toughness are elevated to at least the range of those properties in the best rubber-carbon black compositions. These data emphasize the well-known but interesting fact that stress-strain curves do not necessarily, as proposed by Wiegand, shed much light on practical behavior of rubber under service conditions.

### Elasticity, Hysteresis Loss, and Compression Set

*Elasticity.* Strictly speaking, an elastic deformation is one which disappears entirely on release of the stress which caused it. This definition is simple to remember but difficult to apply. Houwink[13] states "Rubber may be said to be highly elastic, but its deformation is not truly elastic except under certain conditions." The behavior of steel is said to be truly elastic relative to the speed and completeness with which it returns to its original position. Houwink summarized this situation as follows: "The harder and more rigid a material, the more truly elastic is its deformation under a small stress." Returning to our stress-strain curves, it appears that natural rubber is more rigid than butyl rubber. In the lower deformation range it is apparent that more energy will be put into rubber for the same deformation, and it is only reasonable to assume that it will retract more energetically. This is manifested by the phenomenon variously termed "snap" or "nerve." However, it is inconsistent to differentiate the behavior of rubber and steel by the words "highly elastic" and then to consider rubber more elastic than butyl rubber, because it is less "highly elastic" or more rigid.

Whitby[29] introduced the term "elasticity temperature" to describe bodies which may exhibit rubber-like elasticity at temperatures higher or lower than normal. In the light of present knowledge, "temperature range of elasticity" as used by Rosenberg[18] would be more descriptive. Just as lubricating oils differ in their viscosity at different temperatures, so do rubber-like bodies differ in their elastic behavior. Among rubber-like bodies butyl rubber is unique in that it is elastic not only at the normal temperature range of elasticity of rubber but also at much lower temperatures. Practical tests have demonstrated butyl rubber to have usable elastic properties at temperatures as low as —80° F. This is illustrated further by flex resistance tests discussed later.

*Hysteresis Loss.* As measured by the area of the loop confined by the extension and retraction curves with a retraction rate of 3 inches per minute, hysteresis loss may also be related to the stress-strain curve. As Figure 10 shows, there seems to be slightly less loss for rubber. It is possible that the difference

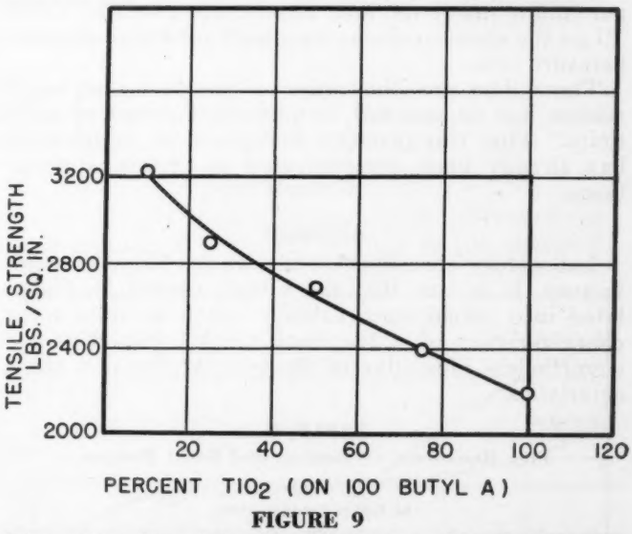



**FIGURE 9**
**Effect of Loading (Titanium Dioxide) on Tensile Strength Butyl A Cured 30 Minutes at 155° C. (311° F.)**

would have been much more marked had the available equipment permitted a comparison at higher retraction rates. However, these data represent only one type of butyl-rubber stock, and no practical evaluation of their significance has been carried out. A more detailed study of the hysteresis properties is now in progress.

*Compression Set.* The A. S. T. M. method calls for

compressing cured cylinders, 0.5 inch thick and 1 square inch surface area, between parallel steel plates under a pressure of 400 pounds. The cylinders are held under this constant pressure in an oven maintained at 70° C. for 22 hours. At the end of this time the cylinders are removed and permitted to rest under no load for 30 minutes. They are then gaged, and this reading is compared with the original thickness. Results are expressed as percent decrease in gage based on the original thickness. The following table compares typical rubber and butyl rubber stocks:

| Sample No. | Percent Gas Black | Percent Compression Set | |
|---|---|---|---|
| | | After 30-Min. Rest | After 1-Week Rest |
| Rubber*..... | About 50 | 8.7 | 6.4 |
| 813..... | 60 | 7.6 | 4.3 |
| 814..... | 70 | 7.6 | 4.8 |

* Commercial first-grade tire tread stock.

## Flexing

Butyl rubber is exceptionally resistant to flexing. The data were obtained on a DeMattia-type flex tester. This machine dynamically flexes samples at a speed of 600 strokes a minute. A sample of commercial first-grade tire-tread stock is compared with more highly loaded butyl-rubber stocks in Tables V and VI.

These results demonstrate that, not only are butyl rubber tire-tread-type compounds initially much more resistant to dynamic flexure but that after long aging they lose little of this resistance, while the natural rubber tread fails rapidly on such severe aging.

Flex cracking rests were also performed at elevated and depressed temperatures. This was done by enclosing the flexing machine in an insulated cabinet provided with a glass window, and heating the machine and the interior of the box with electric heaters or cooling by circulating a refrigerant through copper tubing inside the box. Results are given in Table VI on the same stocks as were used for the room temperature tests.

These data are illustrative of the fact that butyl rubber has an unusual "temperature range of elasticity." That this property has practical significance has already been demonstrated in certain applications.

## Abrasion

Laboratory abrasion test results are likewise satisfactory. It is true that these tests cannot be translated into actual serviceability (such as road wear characteristics of a tire-tread stock), but they are nevertheless indicative of the general abrasion characteristics.

**TABLE V**
**Flex Resistance of Rubber and Butyl Rubber**

| | Natural Rubber | Butyl Rubber |
|---|---|---|
| **At Room Temperature** | | |
| Percent gas black (on gum content)..... | About 50 | 20 } 75 total |
| Percent Gastex..... | ..... | 55 } |
| Hardness (Shore)..... | 58° | 60° |
| Flexures to initial cracking..... | 140,000 | 1,500,000 |
| Flexures to complete cracking..... | 850,000 | 5,000,000 |
| **After Aging Flex Strips 14 Days in Bierer Bomb** | | |
| Flexures to initial cracking..... | 100,000 | 2,000,000 |
| Flexures to complete cracking..... | 400,000 | 4,000,000 |

**TABLE VI**
**Effect of Temperature on the Flex Resistance Rubber and Butyl Rubber**

| FLEXURES | Natural Rubber Tread | Butyl Rubber Tread |
|---|---|---|
| **100° C. (212° F.) TEST** | | |
| To initial cracking..... | 140,000 | Test discontinued after 4,500,000 flexures (no cracking) |
| To complete cracking.. | 2,800,000 | |
| **—22° C. (—7.6° F.) TEST** | | |
| To initial cracking..... | 90,000 | Test discontinued after 1,000,000 flexures (no cracking) |
| To complete cracking.. | 260,000 | |

As has been stated, butyl rubber in comparison with natural rubber may be more heavily loaded with carbon black without undue hardening or stiffening. Tests have shown that 75 to 80 parts of Gastex or gas black may be incorporated before the hardness of the vulcanizates exceeds some 60° Shore; this is in the hardness range of an ordinary natural rubber tire tread containing about 50 parts black. It has also been shown that, while the addition of carbon black may not increase the tensile strength of butyl rubber as it does natural rubber, there are other manifestations of carbon black reinforcement, and abrasion resistance is one of them.

A du Pont abrader was used for laboratory testing. This machine measures abrasion resistance as cubic centimeters loss per horsepower-hour; the lower the loss, the better the abrasion resistance.

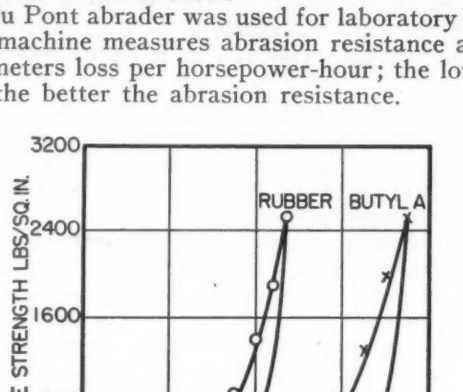


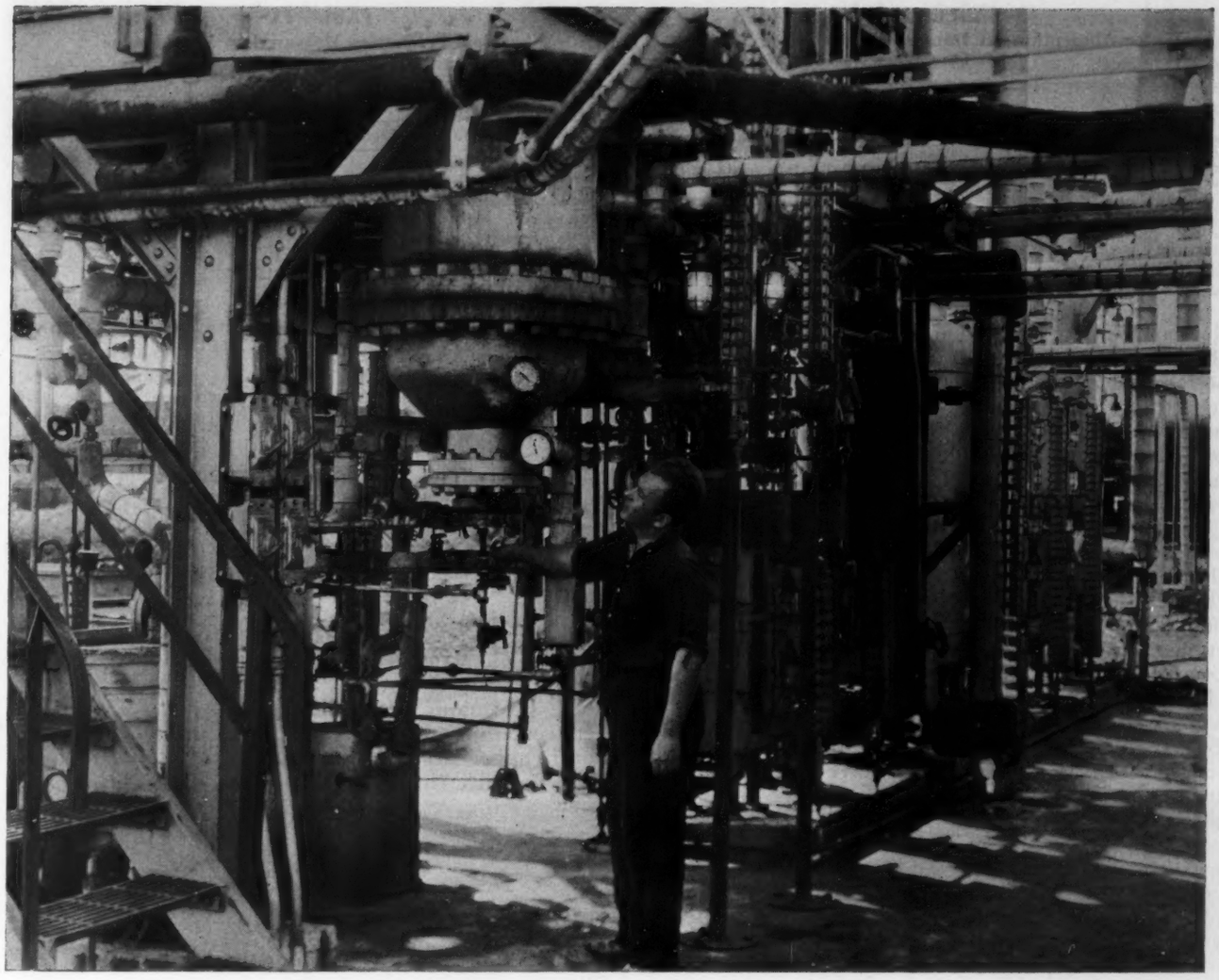

**FIGURE 10**
**Hysteresis Loss on Pure Gum Samples at an Extension and Retraction Rate of 3 Inches Per Minute.**

Table VII shows abrasion-resistance results, before and after 14-day aging in the Bierer-Davis bomb; comparison is made with a commercial first-line rubber tread stock.

The additional volumes of carbon black show their

**TABLE VII**
**Abrasion Resistance of Rubber and Butyl Rubber**

| Sample No. | Percent Gastex | Percent Gas Black | Abrasion Loss, Cc./H.P.-Hr. | |
|---|---|---|---|---|
| | | | Original | 14 Days, Bierer Bomb |
| Rubber..... | .. | About 50 | 210 | 355 |
| 769..... | 60 | 15 | 136 | 96 |
| 770..... | 55 | 20 | 134 | 121 |
| 773..... | 55 | 20 | 122 | 131 |
| 775..... | 55 | 20 | 111 | 130 |



**View of Equipment in Semi-Commercial Butyl Rubber Plant**

presence by conferring higher abrasion resistance on butyl rubber compounds (111 to 136 cc. loss per horsepower-hour compared with rubber's 210 cc.); butyl rubber for its own part demonstrates its exceptional age resistance through the fact that the aged samples are as good as the original.

Although the limitations of such an arbitrary test cannot be too strongly emphasized, the comparison between the effect of aging on the natural and butyl rubber stocks is considered significant.

### Tear Resistance

As in natural rubber, carbon black increases the tear resistance of butyl rubber. Up to the practical

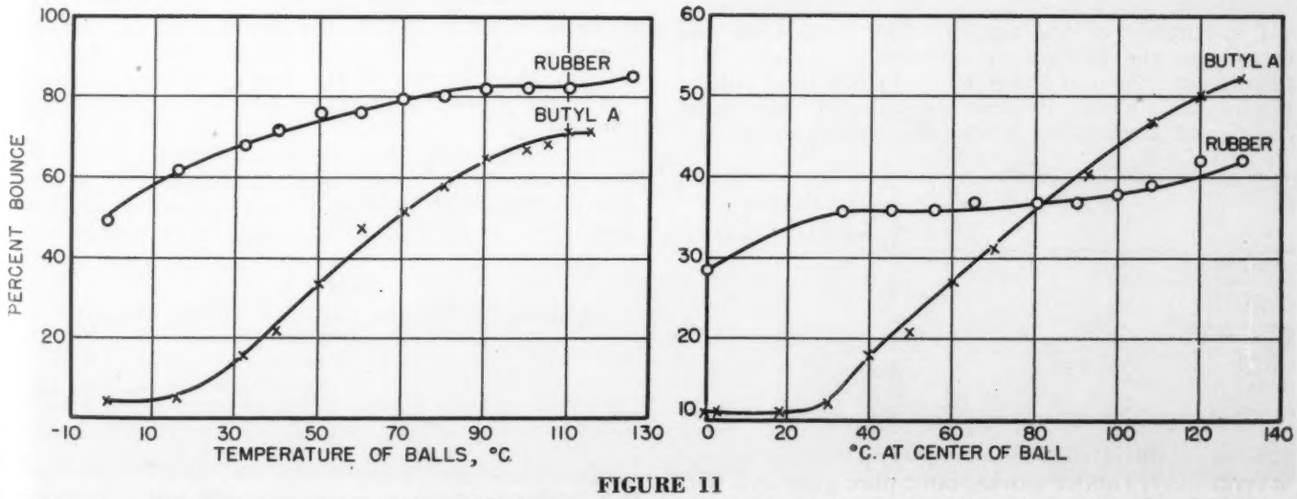



**FIGURE 11**

**Rebound at Various Temperatures of Natural Rubber and Butyl A Balls Dropped on a Steel Plate from a Height of 1 Meter**

**TABLE VIII**
**Water Absorption on Immersion in Boiling Water for One Week**

| TYPE STOCK | Percent Loading (On Total Gum) | Percent Weight Increase |
|---|---|---|
| Rubber 1 | Pure gum | 11.2 |
| Rubber 2 | Pure gum | 12.6 |
| Butyl rubber | Pure gum | 2.9 |
| | 50 Calcene | 5.4 |
| | 50 Gastex | 4.8 |
| | 50 gas black | 2.4 |
| | 50 zinc oxide | 4.9 |
| | 50 P-33 | 4.0 |
| | 50 lithopone | 4.6 |

limit of loading, the higher the carbon black content, the greater the resistance to tear. The carbon blacks so far developed for rubber use have not been found to reinforce the strength of butyl rubber of lowest unsaturation, so that at present a balance between tensile strength and tear resistance of loaded stocks is required (Figure 7).

### Rebound

Assuming, as we have, that butyl rubber merits the designation of being "highly elastic," its rebound characteristics provide some basis for simplifying popular opinions concerning elastic properties. Both rubber and steel have high rebound under normal conditions. Since they are typical examples of "truly elastic" and "highly elastic" bodies, it has been customary to consider rebound as an elastic property. Butyl rubber does not bounce appreciably at room temperature. It does, however, have a high temperature response to rebound and at 100° C. closely resembles the behavior of rubber. Since it undergoes no such marked change in common elastic properties, we may reasonably conclude that elasticity and rebound are not interdependent phenomena. Data comparing the rebound of rubber and butyl rubber at various temperatures are given in Figure 11. Plasticizers such as *p*-cymene greatly accelerate the rebound of butyl rubber at room temperature.

### Water-Absorption Resistance

Resistance to water absorption is important for many applications, such as tank car linings, miscellaneous hose, gaskets, etc.; but it is particularly important when a material is to be used for electrical cable insulation where water absorption by the insulating medium may greatly change the electrical properties and result in failure.

Tests on water absorption were made by immersing specimens in boiling water for one week and measuring the percentage increase in weight. The results are shown in Table VIII. Two natural rubber stocks were used, the first an ordinary pure gum compound, the second, a heat-resisting compound:

| | RUBBER | |
|---|---|---|
| | Stock 1 | Stock 2 |
| Smoked sheets | 100.0 | 87.5 |
| Zinc oxide | 5.0 | 5.0 |
| Stearic acid | 1.0 | .... |
| Paraffin | .... | 2.0 |
| Agerite powder | 1.5 | .... |
| Agerite H. P. | .... | 1.5 |
| Captax | 1.0 | .... |
| Tuads | .... | 3.0 |
| Sulfur | 3.0 | .... |

These natural rubber stocks were compared with several butyl rubber stocks, both pure gum and with various loading pigments.

**TABLE IX**
**Electrical Properties Measured at 1000 Cycles**

| | Butyl Rubber 0.6 | | Natural Rubber 0.5 | |
|---|---|---|---|---|
| Dielectric strength, kv./mil | Dry | Wet* | Dry | Wet* |
| Dielectric constant (1000 cycles) | 2.11 | 2.01 | 2.46 | 2.76 |
| Power factor, percent | 0.04 | 0.05 | 0.04 | 0.16 |

* 88 hours in distilled water; surface wiped dry for measurement.

### Solvent Resistance

Butyl rubber is not primarily a solvent-resisting material. It has, however, the following interesting characteristics:

1. Although it is swelled by aliphatic hydrocarbon solvents as readily as natural rubber, it is more resistant to the simple aromatics, such as benzene and toluene, than some synthetics which now are being used for the construction of gasoline dispensing hose.
2. It is unaffected by such nitrogen-containing solvents as nitrobenzene and aniline.
3. It is relatively unaffected by some halogenated solvents, such as ethylene dichloride, but may swell more than natural rubber stocks in others.
4. It is in general unaffected by oxygenated solvents such as ethers, alcohols, and esters.

### Electrical Properties

As would be expected from a saturated hydrocarbon free from electrolytes in any form, butyl rubber possesses unique electrical properties. A comparison between pure-gum natural rubber and pure-gum butyl rubber is given in Table IX. These data show that the electrical properties are maintained also after soaking in water.

### Gas Permeability

Butyl rubber is a better gas barrier than natural rubber, as judged by tests carried out on a variety of gases. In the case of some of these the rate of diffusion is so low that it has been found difficult to obtain reproducible results. While more accurate determinations are now in progress, the values is Table X are given to show the approximate orders of magnitude.

### Present Status of Development

Butyl rubber is being evaluated for as many of its potential uses as possible by such tests as it has been possible to devise. Because of the dominating importance of the automobile tire field as an outlet for rubber, tests were undertaken on a small scale early in the program to answer the question as to whether or not butyl rubber had any possibilities in this direction. Most of the efforts, however, were concentrated on problems involved in the manufacturing process.

In the meantime, the military authorities had been kept currently informed of the development of this new product, with the result that tests were initiated about two years ago to evaluate butyl rubber for

**TABLE X**
**Approximate Relative Gas Permeabilities Through Pure Gum Stocks**

| Gas | Ratio of Rate of Diffusion through Natural Rubber to Rate of Diffusion through Butyl Rubber |
|---|---|
| Hydrogen | 10–12.5 |
| Helium | 6 or greater |
| Nitrogen | 10–20 |
| Sulfur dioxide | Very great |

more specialized defense uses. When the future supply of natural rubber became a matter of national concern, Standard Oil Development Company was requested by the Army and Navy Munitions Board to cooperate with one or more rubber companies to the end that the suitability of butyl rubber for tire manufacture could be determined at the earliest possible moment. Such a program was promptly undertaken and is still in progress.

Originally the goal of those working in this field was to synthesize a product that would equal natural rubber in those properties which have contributed to make it one of our most important structural materials. The more recent trend is to synthesize materials closely resembling Nature's product in some respects, while at the same time surpassing it in others. In the light of the achievements to date, we are justified in looking forward to the development of a series of synthetics, each one of which will exceed natural rubber in certain specific properties; in the aggregate, therefore, these products will give us something superior to rubber as we know it today. It is felt that butyl rubber possesses properties which will secure an important place for it in this synthetic picture.

Future manufacturing plans will be dependent somewhat upon tests now in progress and to be undertaken more widely when the material is distributed among prospective users. The program being followed with respect to the evaluation of the product for commercial uses is to some extent governed by national defense considerations.


## Acknowledgment

The writers are greatly indebted to many of their associates in the research, engineering, and management groups of Standard Oil Development Company for their contributions to this project.

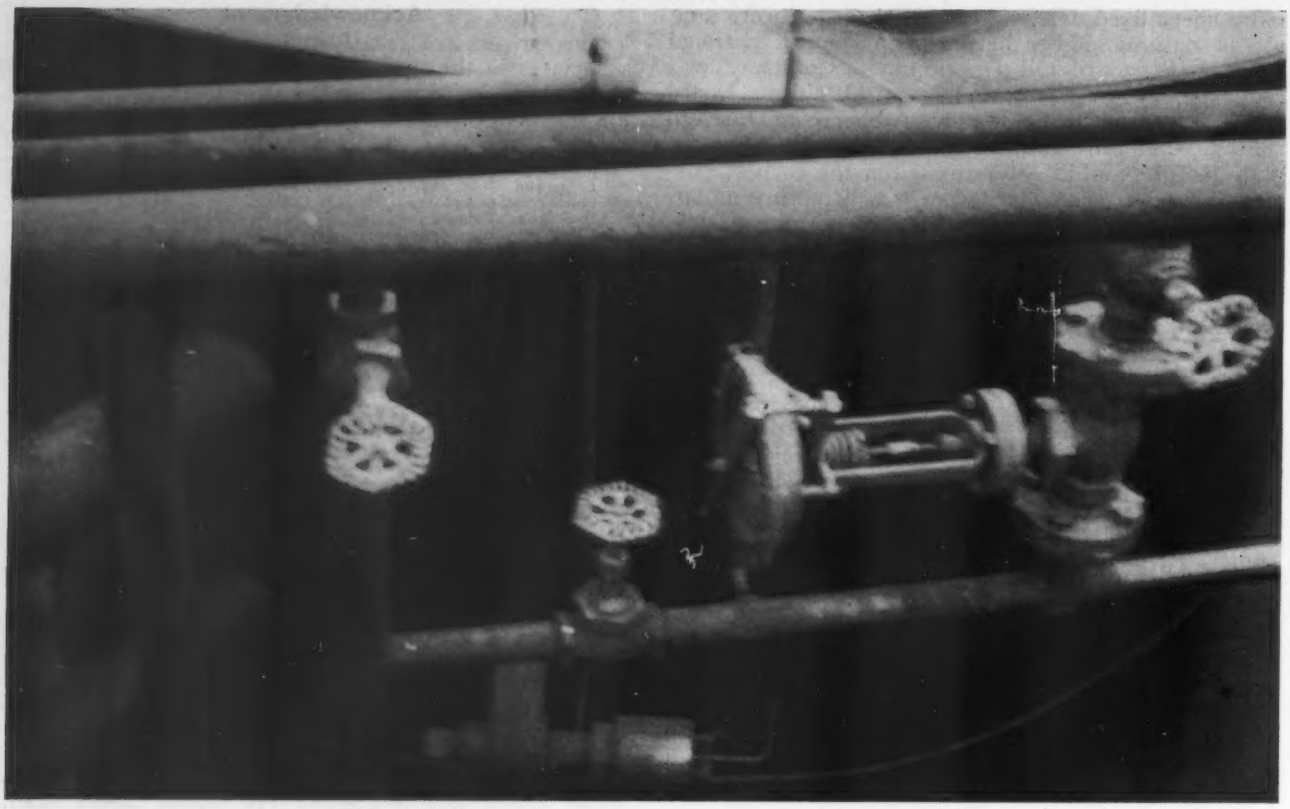

## Literature Cited


[1] Boggs and Blake, *Ind. Eng. Chem.*, **22**, 748 (1930).
[2] Bouchardat, *Compt. rend.*, **89**, 1117 (1879).
[3] Brown and Hauser, *Ind. Eng. Chem.*, **30**, 1291 (1938).
[4] Carothers, *Trans. Faraday Soc.*, **32**, 39 (1936).
[5] Dufraisse, in Davis and Blake's "Chemistry and Technology of Rubber," Chap. XIII, A. C. S. Monograph 74, New York, Reinhold Pub. Corp., 1937.
[6] *Ibid.*, p. 442.
[7] Fikentscher and Mark, *Kautschuk*, **6**, 2 (1930).
[8] Gottlob, *India Rubber J.*, **58**, 305, (1919).
[9] Harries, *Ber.*, **37**, 839 (1904).
[10] Harries, U. S. Patent 1,058,056 (1914).
[11] Hauser, *Ind. Eng. Chem.*, **21**, 249 (1929).
[12] Hoffman, German Patent 250,690 (1911).
[13] Houwink, "Elastizitat, Plastizitat und Struktur der Materie," Leipzig, T. Steinkopff, 1939.
[14] Kondakow, *J. prakt. Chem.*, **62**, 172 (1900).
[15] Mach, *J. Am. Chem. Soc.*, **56**, 2757 (1934).
[16] Mathews and Strange, Brit. Patent 24,790 (1910).
[17] Miller, *J. Chem. Soc.*, **18**, 273 (1865).
[18] Rosenberg, *Proc. Rubber Tech Conf. London*, **1938**, 450.
[19] Schidrowitz and Goldsborough, *J. Soc. Chem. Ind.*, **28**, 3 (1909).
[20] Shepard, Street, and Sharp, in Davis and Blake's "Chemistry and Technology of Rubber," Chap. IX.
[21] Sparks, Lightbown, Turner, Frolich, and Klebsattel, *Ind. Eng. Chem.*, **32**, 731 (1940).
[22] Spence and Scott, *Z. Chem. Ind. Kolloide*, **9**, 83 (1912).
[23] Staudinger, *Ber.*, **53**, 1073 (1920); **62**, 2893 (1929).
[24] Staudinger, in Davis and Blake's "Chemistry and Technology of Rubber," p. 460.
[25] Staudinger and Leopold, *Ber.*, **67**, 304 (1934).
[26] Thomson and Lewis, *Chem. News*, **64**, 169 (1891).
[27] Tilden, *J. Chem. Soc.*, **45**, 411 (1884).
[28] Wallach, *Ann.*, **239**, 48 (1887).
[29] Whitby, *Trans. Ins. Rubber Ind.*, **6**, 46 (1930).
[30] Whitby, *J. Phys. Chem.*, **36**, 198 (1932).
[31] Wiegand, *Ind. Eng. Chem.*, **17**, 623 (1925).
[32] Williams, *Proc. Roy. Soc.*, **10**, 516 (1860).



PRESENTED before the general meeting and before the Division of Rubber Chemistry at the 100th Meeting of the American Chemical Society, Detroit, Mich.

**Crude Butyl Rubber**



**An automatic valve, operated by internal float, starts steam operated pump when receiver is full then shuts off pump when receiver is empty. If pump fails to start when waste oil reached proper level a whistle sounds a warning. This warning also sounds should pump not be shut off when tank is empty.**

# Waste Oil Receiver Automatic in Operation

WITH waste oil gathered from various parts of its gasoline plant at Signal Hill, California, to be disposed of, Gilmore-Dabney, Inc., installed an automatic apparatus to pump this material from the receiving tank. The receiver itself is a 50-barrel steel vessel, set in an excavation so the top deck is about level with the plant grade. It is welded throughout to retain both oil and possible vapors with a vent line standing about 30 feet above the deck to disperse gases to the atmosphere. This vent line extends to the bottom of the vessel. It is slotted from the deck through the distance it passes through the vessel, to allow gases to flow freely, regardless of the height of fluid. A float is placed in the vent line, attached to a cable which extends to the top and runs through a pulley so the float indicator passes up and down through a guide with the target on the plant side to indicate to the operators the level of fluid in the vessel.

Two steam pumps in a concrete pit beside the vessel, are connected to the withdrawal line of the receiver and piped to discharge the fluid to disposition lines leading from the plant. An internal liquid-level float is installed on the vessel with operating air attached through adequate piping in order that the pumps may be started and stopped automatically. In addition to the starting mechanism, a high and low level warning whistle is attached to the remote controller to warn the operators when and if the fluid falls below a predetermined level, or begins to fill above the safe capacity gauge.

As the fluid is gathered and reaches a certain gauge in the vessel, the inside float operates the remote controller, which in turn (through a diaphragm valve) opens steam to the reciprocating pumps. So long as fluid remains in the vessel, between the minimum and maximum gauges, the pump on the line continues to remove the material. When the level drops to the low gauge, the remote controller shuts off the steam, but, should the pump continue to run because of a sticking valve, the warning whistle begins to blow to warn the operator. On the other hand, should the level continue to build up, in excess of the capacity of the pumps, or by failure of the automatic apparatus to open the steam line, the whistle operates on that gauge also.

Since this unit was installed no difficulty has been encountered in the operation of the various parts. It is inspected at intervals to insure that packing, connections and instruments are in good working order.

# The Open Type Cooler

By F. L. KALLAM
President, Industrial Engineers, Inc.,
Los Angeles, California

THE oldest and simplest method of cooling liquids and vapors is to pass them through a coil whose exterior surface is exposed to the flow of water. In this type of apparatus, tubes are generally arranged horizontally in banks so that the water flows from one above to those below. This form is the so-called trombone cooler employed by the heavy chemical, coke, brewing, dairy and refrigeration industries.

Initially the petroleum industry used such coolers but later varied the design to the extent that 3-inch pipe coils were installed directly in the base of cooling towers where they were subjected to the effect of the falling water. Experience with this open type of cooling system resulted in later installations being made with fewer pipes in vertical rows and with smaller diameter pipe. These improvements eventually resulted in the development of shop-fabricated sections consisting of horizontal admiralty metal tubes, usually 1-inch in outside diameter, rolled into cast-iron headers. Such equipment is now the universally accepted standard with refiners employing this type of cooling.

### Advantages of Open Type Coolers

This open type cooling system is considered by many operators to possess several advantages both for the cooling of liquids and for the condensation of vapors. Foremost of these is the feature of ready accessibility for cleaning and replacement of tubes, and the fact that the water requirement of such coolers is relatively low. These shop-fabricated cooling sections are vastly superior when compared to the use of pipe for similar service, principally from the standpoint of first cost, performance, weight, salvage value, area and volume occupied.

Exaggerated claims often have been made for the ability of this type of equipment to shed scale, particularly when the tubes are given an initial bowing. Supposedly, interrupting the flow of cooling water for a brief period, while allowing the hot fluid to continue to flow within the tubes, will cause sufficient tube distortion to crack off the scale which may be present. Stopping the water supply to the equipment and passing steam through the tubes as a heating medium, followed by sudden chilling of the surface by reapplication of the water, will result in a similar effect. Actual experiment and experience, however, have shown that in the greater number of cases these measures will not cause the scale to completely fall from the metal surfaces as claimed. Very often it will result in the cracking and loosening of the scale. An equal effect, however, is obtained with straight tubes because such measures result in expansion of the surface circumferentially as well as longitudinally, whereas the scale itself does not expand. Consequently, there is no advantage of the bowed-tube type of construction over that of the more simple straight-tube design. The harder the scale and the more rigidity it offers, the better it can be loosened by alternate expansion and contraction of the metal surface. More effective so-called self-descaling can be accomplished from waters containing high percentages of permanent hardness.

One advantage which the open type of cooler does have is that the scale formed from the cooling water under the operating conditions can be removed mechanically, and if need be, this can be done without placing the equipment out of service. This generally can be accomplished by carefully hammering the tube surfaces with wooden mallets or by the use of special scraping bars. Oftentimes a high-pressure water hose used in conjunction with these methods will prove advantageous. Open coolers should therefore always be arranged with ample horizontal and vertical, or diagonal, lanes between tubes to facilitate such cleaning. Straight tubes lend themselves most effectively to this requirement. On the other hand, the tube arrangement, or pitch, must be such as to permit none of the cooling water to fall through into the tower basin without striking some part of the cooler surface.

### Disadvantages of Open Type Coolers

The fact that open-section coolers can be operated with large amounts of scale upon their surfaces without affecting the pumping head, as contrasted to the closed-type, is not always as great an advantage as claimed. The cost of descaling open equipment is considerable, aside from being disagreeable work, and this tends to lengthen the operating period between cleanings. As a result, scale deposits of considerable magnitude generally can be observed upon this class of cooler far in excess of that allowed in the conventional closed type of equipment. The deposition of scale upon a surface very naturally offers great resistance to the passage of heat, and consequently lowers the thermal efficiency of the equipment. As this efficiency becomes less the temperature of the cooled fluid rises, and in many plants, this rise is so gradual that it is some time before the fact is realized. In the meantime, the increasing temperature has resulted in daily loss of production, which over a period of time, represents more than the cost of several cleanings. Often this decrease in cooling efficiency is offset for the time being by re-arranging the cooling tower so as to supply the cooler with initially colder water, or water supply over the section is materially increased. Either of these measures represents

an increase in cost. Many plants have been able to operate open equipment in a heavily scaled condition for the reason that they initially were furnished with over-sized coolers affording more surface than required for the load conditions. This is also costly. Still other plants have had their loads decrease from the initial conditions, thus providing additional coolers to compensate for lower cooling efficiency with scaled-surfaces.

Water distribution over such cooling surfaces is affected by variations in daily wind velocities and by continual changes in water concentration caused by either clogging nozzles or troughs. Consequently, certain areas of the scaled surface are alternately wet and dry. This condition results in a scale surrounding a tube which is not in one piece, but is composed of many separate circular layers built one upon the other. With certain types of scale, portions of this outer layer eventually break loose from the scale remaining on the tube and fall from the surface. This feature makes it necessary to observe further precautions in tube arrangements in that the horizontal spacing must be sufficient to allow reasonable scale growth without bridging or blocking the openings between tubes. Secondly, the number of vertical tube rows should be kept at a minimum, never exceeding five as a maximum, in order to lessen the possibilities of falling scale particles lodging between the tubes. It is not uncommon to find the accumulation of these scale particles actually blocking-off over half the cooling surface on sections containing as many or more than eight vertical rows of tubes. A condition such as this is expensive, because the original investment was much larger than it should have been had all the surface purchased been kept reasonably clean.

It should be kept in mind when dealing with the open-type of cooler that such equipment is located within a cooling tower. Because of the demand that water losses be kept to a minimum, the present design of tower has developed into one in which the louvers give no easy access to the interior. To inspect open-coolers, or even to see them, it becomes necessary to open access door louvers in front of a cooler, which permits a view of the section. In the older type of cooling towers such a view can only be obtained by actually crawling into the tower between the louvers. At best, either method is inconvenient, and if the inspection is to be thorough, the water over the cooler must be discontinued. Obviously, the location of the open type of cooler does not enhance its chances of being operated under the most efficient conditions, and it is an excellent example of, "out of sight, out of mind."

### Data Lacking On Open Type Coolers

Despite the fact that the open type of cooling section has found extensive application in the refining industry, and other industries as well, it is surprising that the amount of data available for design purposes is so small. This dearth of design data is particularly felt in connection with the prediction of the amount of cooling water required for a given service, the value of the outside heat transfer coefficient, and the value to affix to the factor stating the degree of scaling allowed for upon the cooling surface. To secure such basic information in a commercially operated plant is practically next to impossible for numerous reasons, and as a result, difficulty has always been encountered in rating the performance of such sections and comparing one with another. Obviously, the very nature and location of this class of equipment offers considerably more of a test problem than does the conventional shell-and-tube type of cooler. These facts explain why the open type of cooler has been practically ignored in published literature, and why the design of such equipment is still in the "rule of thumb" stage.

### Principle of the Open Type Cooler

To understand the functioning of the open-type cooler, it is first necessary to recognize the cardinal principle that the heat removed is ultimately dissipated to the air. If the tubes are flooded with water it may be assumed that no evaporation takes place and that all of the heat is removed by raising the temperature of the water. Should it be desired to again use this heated water, as in the usual case, it is re-circulated over the top of the cooling tower where the heat it contains is released to the air.

When a smaller quantity of cooling water is employed to remove the heat it is necessary actually to evaporate this water from the exterior of the tubes and to transmit the heat to the surrounding air. This air is caused to flow past the cooler section by either natural or artificial draught through the cooling tower. Thus by maintaining a thin but complete water film upon the tubes, evaporation will take place continuously, thereby removing heat from the fluid within the tubes. The extent of this evaporation will be governed by the difference between the vapor pressure of the water at the tube surface conditions and the partial pressure exerted by the moisture carried in the air stream.

It is very doubtful if in any commercial installation all of the heat is removed entirely by evaporation or through sensible heat alone. In most cases, it will be found to be removed by a combination of both of these effects.

In the usual installation, the amount of heat lost from within the tubes is never entirely accounted for as sensible heat gained by the cooling water. This is due to the fact that considerable evaporation has taken place upon the surface of the cooler. Because all of the heat removed cannot be accounted for as sensible heat in the cooling water, it is difficult to predict in advance the actual amount of water required for a given cooling service. This condition has developed the practice of selecting the required water rate based on a temperature rise consistent with past experience, and to totally neglect the factor of evaporation.

### Evaporating Effect of Cooling Water

Such a procedure can result in grave error as developed from a series of carefully conducted tests upon various types of available cooling sections. These sections were equipped with means for accurately measuring the water on and off the surfaces, and for obtaining the resulting temperature changes. Heated water was circulated through the tubes of these coolers at definite rates, and from the change in temperature from inlet to outlet, the heat removed was determined for each case. The difference between the heat lost by the water within the tubes and the sensible heat gained by the cooling water represents the amount dissipated by evaporation of a portion of the cooling water.

In all, 45 different tests were made in which the

following variables were observed through the ranges indicated:

Cooling water rate, 3 to 38 lbs./sq. ft. (min. of projected cooling surface).

Water velocity within tubes, 2 to 14 ft./sec.

Wind velocity and direction at cooling tower, 10 to 1,000 ft./min.

Temperature cooling water to section, 60 to 78° F.

Temperature cooling water off section, 88 to 120° F.

Temperature water to tubes, 109 to 153° F.

Temperature water from tubes, 90 to 141° F.

Dry bulb temperature, 60 to 76° F.

Wet bulb temperature, 54 to 66° F.

Heat removed by evaporation of cooling water, 0.4 to 50.0% of total.

As might be expected from the nature of the equipment tested, a rational correlation of the data obtained was not possible. The results were partially conclusive in several respects, however, and indicated that the direction and velocity of the wind, together with the relative humidity, had no uniform influence upon the amount of heat removed in the evaporation of a portion of the cooling water. These factors were therefore discarded in the final correlation. The governing factors of the problem were shown to be the cooling water concentration rate upon the cooling surface, the logarithmic mean temperature of the cooling water striking and leaving the cooling surface, and the design or arrangement of the cooling surface itself.

Figure 1 is a plot of the data from these tests and shows a definite trend toward correlation based upon the factors selected. In general, the data show for a cooling water circulation of 1900 lbs./sq. ft./hr., or greater, (Factor MT=2500 plus), that the heat removed by evaporation will vary from 0 to 13 percent. In this range, the cooler may be considered as operated, "flooded." When the cooling water rate is kept below 300 lbs./sq. ft./hr., (Factor MT=450 or less), at least 33 percent or more of the total heat load will be removed by evaporation. This type of operation may be termed, "evaporative." Ordinary operation of open sections varies within water rates between the above values, or in range of 300 to 1900 lbs./sq. ft./hr., (Factor MT=450—2500), which normally may represent an evaporative heat removal between 13 and 33 percent. For the test conditions, the average heat removal for this normal operating range (MT=450—2500) was 17.5 percent.

### Determination of the Cooling Water Rate

It is now in order to demonstrate how the data of Figure 1 may be used. Assume that it is desired to remove 1,000,000 B. t. u. per hour in an open-type cooler composed of 1-inch O. D. tubes. These tubes are spaced horizontally on 2-inch centers and vertically on 1-inch centers. Let the design be such that the vertically projected area of the tube surfaces to the water spray is 80 square feet, and that this water is at a temperature of 70° F. Assume further that the temperature rise of the cooling water is to be limited to 10° F., or that the temperature of the water flowing from the cooler will be 80° F. For these conditions, what is the correct amount of cooling water to circulate?

Normally this problem would be solved by determining the amount of water required, allowing a 10° rise, to remove 1,000,000 B. t. u./hour. The answer in this case would be

$$\frac{1{,}000{,}000}{60\times 8.33\times 10}=199 \text{ g. p. m.}$$

This rate represents a spray concentration over the cooler of

$$\frac{199\times 8.33}{80}=20.7 \text{ lbs./sq. ft./min.}$$

Let this rate be determined by the use of Figure 1. To do this, it is first necessary to set forth the characteristics of the cooler. The outside tube diameter (D) may be stated as 1/12=0.0835 feet, and the horizontal tube spacing (P) at 2/12=0.168 feet. Factor (X) then becomes

$$\frac{0.168-0.0835}{0.168}=0.5$$

and (Y) becomes

$$\frac{0.160-0.0835}{0.0835}=1.0$$

The value of (DXY) can now be determined as $0.0835\times 0.5\times 1.0=0.04175$, and $(DXY)^{0.1}=0.7278$.

The logarithmic mean temperature (T) of the water on and off the cooler is found to be 75° F. This permits (MT) to be evaluated at (75M).

Assumed that the heat removed (E) from the cooler by evaporation of a portion of the cooling water will be 18.4 percent. This assumption permits the calculation of the heat removed through evaporation of the spray water, and is $0.184\times 1{,}000{,}000=184{,}000$ B.t.u./hr. By difference, the heat dissipated in increasing the temperature of the spray water from the cooler can be found. This value is 1,000,000—184,000=816,000 B.t.u./hr. Introducing the value of

$$\frac{E}{(DXY)^{0.1}} \text{ or } \frac{0.184}{0.7278}=0.253,$$

into Figure 1, the factor (MT) is found to be 1278. But as (MT) has already been found to be equal to (75M), the value of (M) becomes

$$\frac{1278}{75}=17.02 \text{ lbs./sq. ft./min.}$$

It is now possible to determine the heat carried away from the cooler solely through temperature rise in the cooling water, and this value is

$$17.02\times 80\times 60\times 10\times 1=817{,}000 \text{ B.t.u./hr.}$$

Had this value not closely approximated the originally assumed value of 816,000, the calculation would be repeated, using other choices for "E" until a reasonable check was obtained.

The correct amount of cooling water required to meet the specified service conditions can now be determined. This rate is

$$\frac{17.02\times 80}{8.33}=164 \text{ g.p.m.}$$

as against 199 g.p.m. obtained without consideration of the effect of evaporation. The difference in rates, namely, 35 g.p.m., represents an error of 21.3 percent. This variation demonstrates the need for considering the evaporating effect of the spray

water when designing the open-type cooler or considering its possible installation.

### The Film Concept of Heat Transfer

The actual heat transfer surface required in the open type of cooler or condenser for a definite service is now estimated primarily from past performance with similar conditions. Only the overall factor of heat transfer is thereby used with no consideration given to the various resistance to heat flow offered by the two fluids and the tube wall between them. The use of the overall coefficient of heat transfer in this manner is all well and good for expressing the thermal efficiency of the section, but leaves much to be desired when it is necessary to predict the performance for other operating conditions. A definite overall heat transfer coefficient exists for an open section operating with fixed fluid conditions within and without the tubes. Assuming that it is desired to increase this heat transfer rate, would, for example, increasing the fluid velocity within the tubes or increasing the spray water concentration on the outside surface be of greater benefit? This question can be answered by a knowledge of the film coefficients on each side of the tube surface, and their variation with velocity and other factors. Thus the problem of heat transfer from a liquid outside to a liquid inside a tube can be determined best by a consideration of the magnitude of the individual film coefficients.

It is now accepted that when a fluid flows along the surface of a tube there is a relatively stationary film of that fluid adhering to the metal surface. The heat can only be transferred through such a film by means of conduction. Since practically all fluids are notoriously poor thermal conductors, this film offers considerable resistance to the passage of heat. In fact, as compared to these liquid film resistances, the metal of the tube itself offers relatively no resistance to the passage of heat and can in most instances be disregarded.

### Heat Resistance Factors

The transfer of heat from a fluid outside a tube to a fluid within the tube is therefore dependent upon a series of resistances which are as follows:

1—Resistance of the fluid film on the outside of the tube.
2—Resistance of the metal tube wall.
3—Resistance due to scale present on both sides of the tube wall.
4—Resistance of the fluid film on the inside of the tube.

In practice the thickness of these fluid films cannot be measured directly, or predicted, and hence an indirect method must be used to express their effect upon the heat transferred. Such a method was developed by Nusselt and permits the use for all practical purposes of the familiar resistance concept formula:

$$K=\frac{1}{\frac{1}{h_i}+\frac{L}{k_t}+\frac{1}{h_s}+\frac{1}{h_o}}$$

Where K=Overall heat transfer coefficient, B.t.u./hr./sq. ft./°F.
$h_i$=Film heat transfer coefficient inside tubes, B.t.u./hr./sq. ft./°F.
$h_o$=Film heat transfer coefficient outside tubes, B.t.u./hr./sq. ft./°F.
$h_s$=Film heat transfer coefficient for scale, B.t.u./hr./sq. ft./°F.
L=Wall thickness of tube, ft.
$k_t$=Thermal conductivity of tube, B.t.u./hr./sq. ft./°F./ft.

From this relationship between the individual coefficients and the overall coefficient, the latter can readily be calculated, thereby permitting use of the general heat transfer equation, which is:

Q=K A T, where,
Q=Heat transferred, B.t.u./hr.
K=Overall heat transfer coefficient, B.t.u./hr./sq. ft./°F.
T=Mean temperature difference across the heating surface, °F.
A=Area through which heat is transferred, sq. ft.

### Determining the Inside Film Coefficient

More data are available for predicting the inside film coefficient than for the case of fluid flow outside the tube. This condition naturally would follow because inside flow presents fewer mechanical difficulties in conducting the necessary experimental work. Despite these advantages, sufficient dependable data are not yet available to warrant a general equation for the inside film coefficient which will allow for all the factors which may be involved. However, for the more important commercial applications, where the flow is turbulent, the Dittus and Boelter equation may be used for the determination of the inside film coefficient. This is:

$$\frac{h_i D}{k}=0.0225\left(\frac{DG}{2.42Z}\right)^{0.8}\left(\frac{2.42CZ}{k}\right)^{0.4}$$

where,

$h_i$ = Inside fluid film coefficient, B.t.u./hr./sq. ft./°F.
D = Inside diameter of tube, ft.
k = Thermal conductivity of fluid, B.t.u./hr./sq. ft./°F./ft.
G = Mass velocity of fluid, lbs./hr./sq. ft. cross section of tube
Z = Viscosity of fluid, centipoises
C = Specific heat of fluid, B.t.u./lb./°F.

All physical properties of the fluid are evaluated at the arithmetic mean of the terminal temperature.

Petroleum oils, however, through a part of the turbulent flow range, do not obey the Dittus and Boelter equation. In the graph of this equation, Figure 2, values of

$$\left(\frac{DG}{2.42Z}\right)$$

between 2100 and 7000 for oils must be taken from the curved portion of the plot.

The values of the inside film heat transfer coefficient obtained from Figure 2 for hydrocarbon oils are for the case when heat is flowing from the metal tube wall to the oil. When cooling these oils, or when the heat flows from the oil to the metal wall, values of the film coefficient ($h_i$) obtained from the plot must be reduced by 25 percent. This reduction is necessary because of the great difference between the temperature of the oil film at the tube surface and the temperature of the main body of oil in the tube.

### The Outside Film Coefficient

Although the data available for predicting the inside film coefficient are far from complete, that pertaining to fluid flow upon the outside of the tubes is much less satisfactory. Experimental data for this case are limited, and do not justify a general equation to the extent given above for the inside of the tubes. Tubular heat exchangers, in general, cannot be designed on the basis of any calculated coefficient, but must be investigated experimentally. Nat-

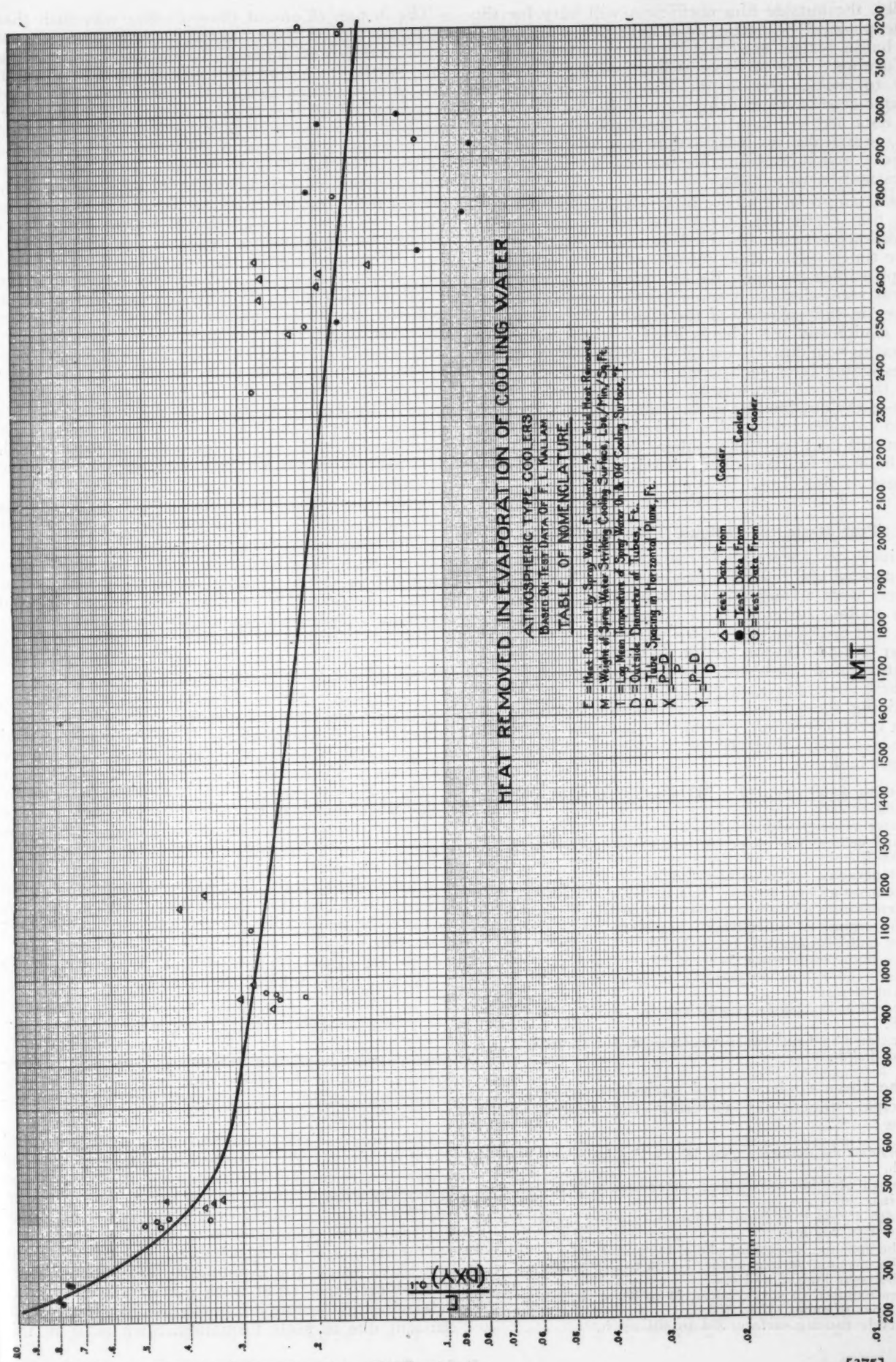

HEAT REMOVED IN EVAPORATION OF COOLING WATER
ATMOSPHERIC TYPE COOLERS
Based On Test Data Of F. L. Nallam
TABLE OF NOMENCLATURE
E = Heat Removed by Spray Water Evaporated, As a Total Heat Removed.
M = Weight of Spray Water Striking Cooling Surface, Lbs./Min./Sq.Ft.
T = Log Mean Temperature of Spray Water On & Off Cooling Surface, °F.
D = Outside Diameter of Tubes, Ft.
P = Tube Spacing in Horizontal Plane, Ft.
X = P−D / P
Y = P−D / D
△ = Test Data From Cooler.
● = Test Data From Cooler.
○ = Test Data From Cooler.
MT
E / T^1.0 (DXY)^0.1

FIGURE 1

urally, the outside film coefficient will vary for the same physical properties of a fluid depending upon the baffle system used and its arrangement.

Turning to the problem at hand where it is desirable to predict the outside film coefficient for the specific case of water dripping over horizontal tubes, the data are still in a more unsatisfactory state. In fact, practically no information is available on this subject, and it was for this reason that the present investigation was made.

In attempting to secure information upon the outside film coefficient, it was decided to conform to conditions actually obtained in practice and at the same time to gain some knowledge of the fundamental principles involved. By following such procedure it was recognized that some sacrifice would be necessary in the accuracy of the results, since commercial equipment never lends itself to rigid control of operating conditions, especially when the problem investigated is of such complex nature. Despite the fact that no attempt was made to measure the thickness of the outside film or the tube wall temperature, or to consider many other desirable factors bearing upon this heat-transfer problem, the results obtained are believed to have a very definite commercial usefulness at this time.

### Test Basis for Outside Film Coefficient

Ninety tests were made upon 3 different standard commercial fabricated open type coolers. These coolers were arranged in the base of an atmospheric type cooling tower in the conventional manner, except that provision was made for measuring the spray water on and off each section. Water at various temperatures and rates was circulated through the tubes of these coolers and permitted a means for accurately obtaining the amount of heat actually removed for each given condition. During the tests the following variables were observed or calculated through the ranges indicated:

Cooling water rate, 180 to 2400 lbs./hr./sq. ft. of projected cooling surface.
Water velocity within tubes, 2 to 14 ft./sec.
Wind velocity and direction relative to cooling tower, 10 to 1000 ft./min.
Temperature spray water to cooler, 60 to 78 °F.
Temperature spray water from cooler, 81 to 120 °F.
Temperature of water to tubes, 109 to 153 °F.
Temperature of water from tubes, 90 to 141 °F.
Dry bulb temperature, 60 to 76 °F.
Wet bulb temperature, 54 to 66 °F.
Heat removed by evaporation of spray water, 0.4 to 50 percent of total.
Overall heat transfer coefficient, 61 to 341 B.t.u./hr./sq. ft./°F.
Outside film heat transfer coefficient, 102 to 2825 B.t.u./hr./sq. ft./°F.

The three coolers tested varied in design, their principal dimensions covering the ranges given below:

Outside tube diameter (No. 18 BWG Admiralty), ¾- and 1-inch.
Length of tubes exposed to water spray, 12 ft. to 19 ft. 10½ ins.
Width across tube bank, exposure to water spray, 2 ft. 7 ins. to 4 ft. 2¾ ins.
Tube spacing, horizontal plane, 1⅜ and 2 ins.
Tube spacing, vertical plane, 1-5/16 to 2-9/16 ins.
Tube rows high, 3 and 4.
Area exposed to spray water, 31 to 84 sq. ft.
Number of tubes, 57 to 104.
Outside cooling surface, 204 to 404 sq. ft.

The design of one of these coolers was such that the water to be cooled entered the bottom row of tubes and flowed upward through each succeeding row. In the remaining two coolers, the flow through the tubes was arranged so that each pass contained a number of vertical rows of tubes. With this type, the cold spray water striking the section contacted the warmest water within the tubes as well as the coldest in the last pass. In the case of the first cooler, however, the cold spray water initially strikes only the tubes in the last pass, or those tubes carrying water which has been previously cooled in the rows of tubes below. Thus it is apparent that the temperature difference between the water to be cooled and the spray water varies continuously throughout the length of the coolers. Only in the case of the single cooler is counterflow approached, while the flow in the other two types of coolers cannot even be partially classified. In order to obtain an average temperature difference between the fluid in the tubes and the spray water, the conventional logarithmic-mean of the terminal differences has been used. This was an arbitrary choice, since its use violates the assumptions made in the derivation of the method, and cannot therefore be justified on scientific grounds.

With the information obtained from the test runs and the use of the previously stated general heat transfer equation, the overall heat transfer coefficient was calculated for each test. The reciprocal of this value, by previous definition, is equal to the sum of all the four thermal resistances. Now if three of these resistances are known, the fourth can readily be computed. There is thus afforded the means for obtaining the film coefficient upon the outside of the tubes for the open type coolers investigated.

In carrying out this portion of the investigation, the inside film transfer coefficient was first determined for each test condition. This was accomplished by use of the Dittus and Boelter equation, or more particularly by the use of a curve similar to Figure 2. The physical properties of the water within the tubes were taken at the logarithmic mean average of the water temperature entering and leaving the cooler. Solution by means of Figure 2 is straightforward and results in the determination of the inside film coefficient. It is necessary to correct this coefficient to the outside surface by multiplying by the ratio of the inside tube diameter to the outside tube diameter.

The resistance offered to heat flow through the Admiralty metal tubes is found to be:

$$\left(\frac{L}{k_t}\right) = \frac{0.0490}{12 \times 63} = 0.000065$$

The magnitude of this resistance is so small compared to that of the inside fluid and total scale that it may conveniently be disregarded without adversely affecting the results.

The three coolers tested were new equipment and the fluid circulated through the tubes was distilled water. Water contacting the outside of the tubes was better than the ordinary run of plant cooling water, but did contain a slight degree of hardness. All of the tests were conducted and completed within a period of approximately 25 days. The tests run the first day, when the equipment was commercially clean, were repeated at weekly intervals in order to determine the decline in the overall heat transfer coefficient due to scale formation. Such scale in this

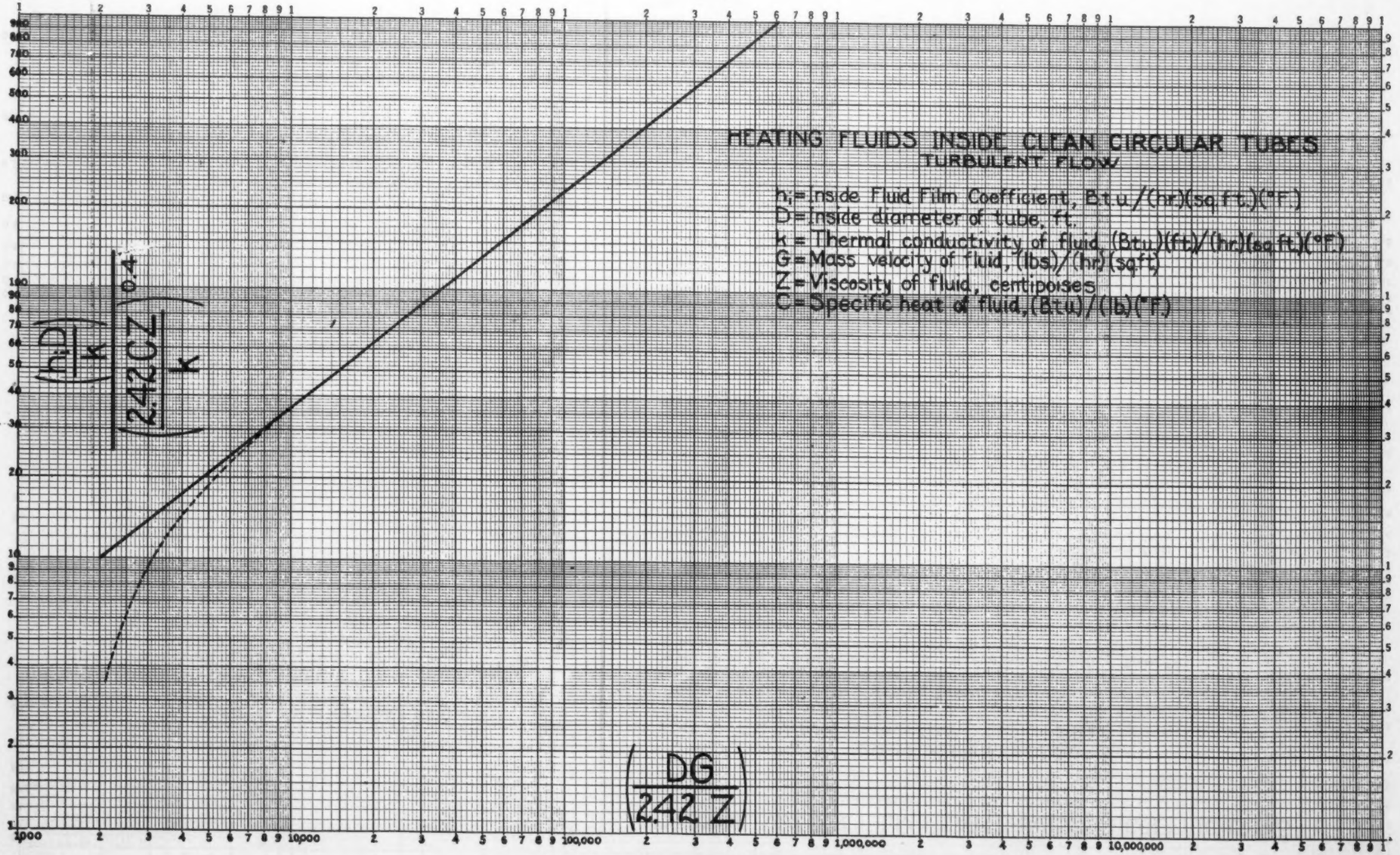

HEATING FLUIDS INSIDE CLEAN CIRCULAR TUBES
TURBULENT FLOW
$h_i$ = Inside Fluid Film Coefficient, Btu/(hr)(sq ft.)(°F.)
D = Inside diameter of tube, ft.
k = Thermal conductivity of fluid, (Btu)(ft)/(hr)(sq ft.)(°F.)
G = Mass velocity of fluid, (lbs)/(hr)(sq ft.)
Z = Viscosity of fluid, centipoises
C = Specific heat of fluid, (Btu)/(lb)(°F.)
$\left(\frac{h_i D}{k}\right)\left(\frac{2.42 Z}{k}\right)^{.04}$
$\left(\frac{DG}{2.42 Z}\right)$

FIGURE 2

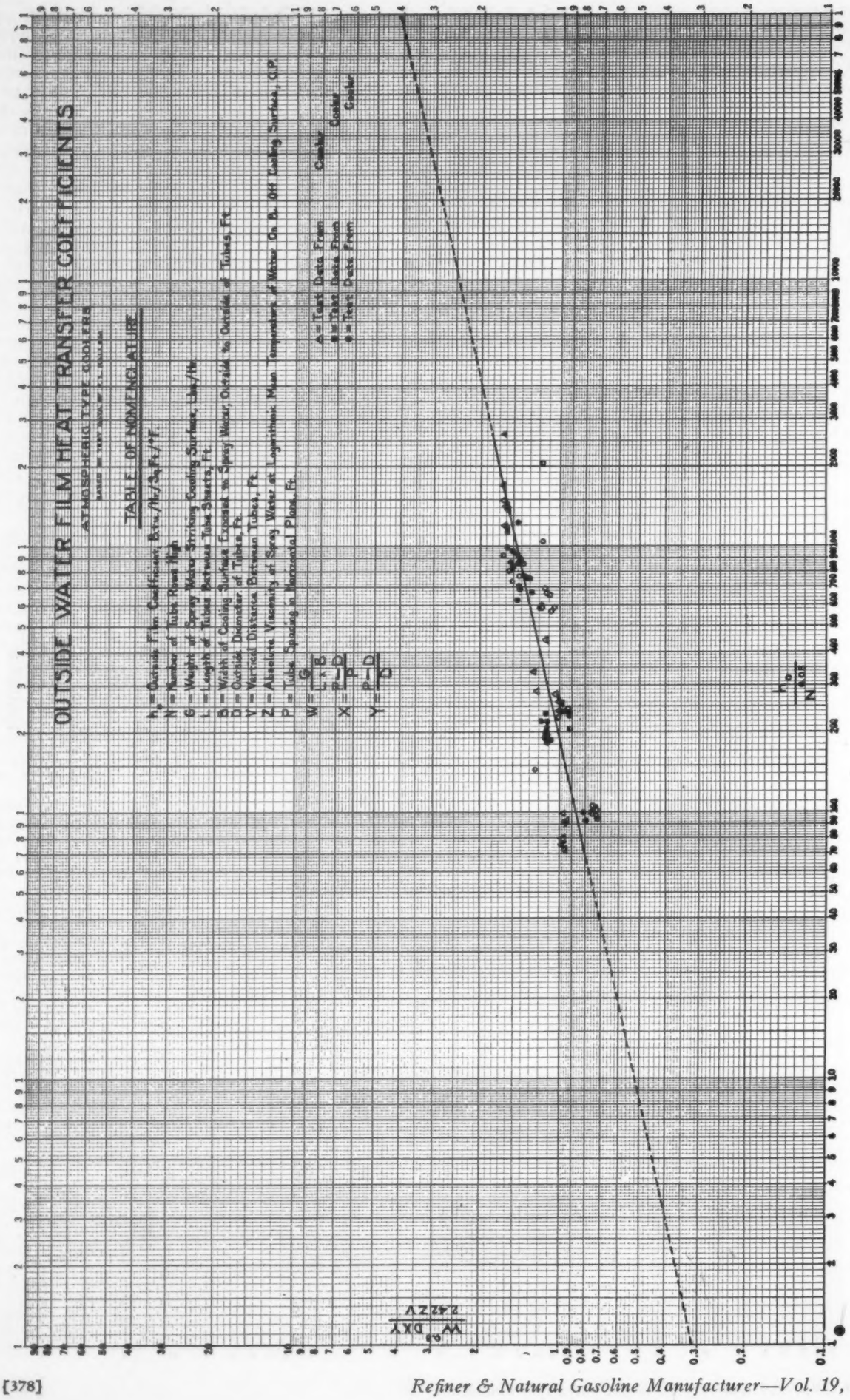

OUTSIDE WATER FILM HEAT TRANSFER COEFFICIENTS
ATMOSPHERIC TYPE COOLERS
TABLE OF NOMENCLATURE
$h_o$ = Outside Film Coefficient, Btu./hr./Sq.Ft./°F.
N = Number of Tube Rows High
G = Weight of Spray Water Striking Cooling Surface, Lbs./Hr.
L = Length of Tubes Between Tube Sheets, Ft.
B = Width of Cooling Surface Exposed to Spray Water, Outside to Outside of Tubes, Ft.
D = Outside Diameter of Tubes, Ft.
V = Vertical Distance Between Tubes, Ft.
Z = Absolute Viscosity of Spray Water at Logarithmic Mean Temperature of Water On & Off Cooling Surface, C.P.
P = Tube Spacing in Horizontal Plane, Ft.
$W = \frac{G}{L \times B}$
$X = \frac{P-D}{P}$
$Y = \frac{P-D}{D}$
A = Test Data From Cooler
B = Test Data From Cooler
C = Test Data From Cooler
$\frac{h_o}{N^{.60}F}$
$\frac{W^{.67} DXY}{2.42ZV}$

FIGURE 3

case was essentially all on the outside of the tubes and at the termination of the tests was not discernible except possibly at that point in the surface where the hot distilled water entered. From the decline in heat transfer efficiency for the duration of the tests, a fair value for the resistance of the scale was found to be 0.002.

### Outside Film Coefficient Derived from Test Data

As pointed out before, knowing the values of the three resistance factors and the overall heat transfer coefficient, the outside film factor is obtainable. Actually, only two resistance factors need be considered since the third, representing the resistance of the metal tube, can be disregarded. These computations were made for the test conditions and the outside film coefficient determined based upon clean tube surfaces.

In order that the outside thermal film coefficient for water dripping over horizontal tubes, as determined from these tests, can be of service, it must be placed in some form which makes its use fairly simple. The data so found has therefore been correlated as shown in Figure 3. This correlation is based upon the plot of the factor

$$(h_o/N^{0.05}) \text{ against } (W^{0.3}DXY) \div (2.42ZV),$$

wherein the data in general support a straight line upon logarithmic paper. The factors so utilized have the following nomenclature:

$h_o$ = Outside thermal film coefficient, B.t.u./hr./sq. ft./°F.
N = Number of tube rows high.
G = Weight of spray water striking cooling surface, lbs./hr.
L = Length of tubes exposed to spray water, ft.
B = Width of cooling surface exposed to spray water, ft.
D = Outside diameter of tubes, ft.
Z = Absolute viscosity of spray water at logarithmic mean temperature of spray water on and off cooling surface, centipoises
P = Tube spacing in horizontal plane, ft.
V = Vertical distance between tubes, ft.

$$W = \frac{G}{L \times B}$$

$$X = \frac{P-D}{P}$$

$$Y = \frac{P-D}{D}$$

Therefore the empirical and recommended equation for the outside film coefficient, as derived from this test data, is:

$$h_o = 190N^{0.05}\left(\frac{W^{0.3}\,DXY}{2.42\,ZV}\right)^{0.4}$$

The use of this equation, in conjunction with existing equations for calculating coefficients of heat transmission inside tubes, will permit the design of the open type cooler. In so doing, allowance must be made for the thermal resistance of possible scale formation, although that due to the tube itself in most instances can be disregarded.

### The Scale Coefficient

The practical usefulness of all film coefficients depends upon the condition of the metal surfaces through which the heat passes. Fouling of the surface cannot be eliminated and hence it presents one of the major problems in the design and operation of all types of heat exchangers. So inadequate is the present knowledge that the resistance offered to heat flow by these scale or dirt accumulations is never exactly known. Obviously, no exact rules for predetermining the extent of fouling or scaling can be given.

Just why the prediction of the effect of scale upon the heat transfer surface remains to be a troublesome problem is apparent from the following considerations. The conduction of heat through the scale is governed by the equation:

$$Q = \frac{k_s\,AT_s}{L_s}$$

where

Q = Heat transferred, B.t.u./hr.
$T_s$ = Temperature difference between the two sides of the scale film, °F.
$K_s$ = Thermal conductivity of scale, B.t.u./hr./sq. ft./°F./ft.
$L_s$ = Thickness of scale film, ft.
A = Area through which heat is transferred, sq. ft.

Or, the heat passage may be allowed for by the familiar relationship:

$$Q = h_s\,AT_s$$

where

$h_s$ = Film heat transfer coefficient for scale, B.t.u./hr./sq. ft./°F.

By combining these two equations, the value of the film transfer rate through the scale deposit can be obtained in terms of thickness of the scale body and its conductivity, or,

$$h_s = \frac{k_s}{L_s}$$

But, by definition for unit area, thermal resistance is equal to the reciprocal of the film coefficient, and it may be stated that:

$$r_s = \frac{1}{h_s} = \frac{L_s}{k_s}$$

where

$r_s$ = Thermal resistance to heat flow through scale film.

From the complexity of the necessary work involved it can be said that few values of ($h_s$) have ever been directly determined. Providing information relative to ($L_s$) and ($k_s$) are at hand, the value of ($h_s$) becomes readily available. Unfortunately, the determination of the thickness of commercial scale deposits is not practical. The same condition applies to the determination of the scale conductivities which must be experimentally obtained.

In addition to the actual physical characteristic of the scale itself, several other factors influence its total resistance to the flow of heat, thereby complicating the problem still more. In this, temperature, especially the film temperature, plays a leading part. Low temperatures in oil films may cause a waxy deposit at the metal surface since at this point the temperature is below that of the main stream. In a similar way, high temperatures in oil or water films will result in a deposition of hard scale since the metal surface will be at a temperature higher than that of the main body.

Fluid velocity also has a decided effect upon the scale formation, particularly in the case of deposits of a loose nature. Velocities higher than four feet per second often effectively keep the surface wiped relatively free of such deposits. With hard tight scales this effect is practically negligible, although the

**TABLE 1**

**Minimum Scale Resistances for Fluids Being Cooled Inside Tubes**

| Fluid | SERVICE | Scale Resistance |
|---|---|---|
| Gases and Vapors | Air | 0.002 |
| | Manufactured gas | 0.01 |
| | Natural gas | 0.0015 |
| | Organic vapors | 0.001 |
| | Overhead vapor from cracking plant bubble tower | 0.002 |
| | Debutanizer plant bubble tower | 0.001 |
| | Lube. Oil treating plant tower | 0.001 |
| | Natural gasoline plant bubble tower | 0.0005 |
| | Natural gasoline stabilizer bubble tower | 0.0005 |
| | Refinery vapor recovery plant bubble tower | 0.001 |
| | Topping plant bubble tower (Untreated) | 0.001 |
| | Topping plant bubble tower (Treated) | 0.003 |
| | Vacuum plant bubble tower | 0.001 |
| | Vacuum plant flash tower | 0.003 |
| | Refinery vapors | 0.003 |
| | Refrigerating plant vapors (from reciprocating compressor) | 0.002 |
| | Separator, flash pot and vaporizer vapors from cracking plant | 0.006 |
| | Steam (Oil-free) | 0.000 |
| | Steam (Exhaust from reciprocating machine) | 0.005 |
| Liquids | Oil, asphalt and resin | 0.01 |
| | Crude | 0.002 |
| | Crude (Wet, below 200° F.) | 0.002 |
| | Crude (Wet, above 200° F.) | 0.004 |
| | Debutanizer feed and product | 0.001 |
| | Distilled bottoms above 25° A. P. I. Gravity | 0.002 |
| | Oil, Fat and Lean, natural gasoline plant | 0.001 |
| | Fat and Lean, refinery vapor recovery plant | 0.002 |
| | Gasoline | 0.0005 |
| | Gas, cracking plant | 0.0025 |
| | Machinery and transformer | 0.001 |
| | Naphtha, cracking plant | 0.003 |
| | Quenching | 0.004 |
| | Refined lube | 0.003 |
| | Residual bottoms, less than 25° A.P.I. Gravity | 0.005 |
| | Residuum, cracking plant | 0.01 |
| | Side stream cuts | 0.001 |
| | Vegetable | 0.003 |
| | Organic liquids | 0.001 |
| | Refrigerating liquids | 0.001 |
| | Solvents | 0.001 |
| | Water, Brackish | 0.002 |
| | City | 0.001 |
| | Cooling tower (treated make-up) | 0.001 |
| | Cooling tower (Untreated make-up) | 0.004 |
| | Distilled | 0.0001 |
| | Engine jacket | 0.001 |
| | Hard, over 15 Grs./gal. | 0.003 |
| | River | 0.003 |
| | Sea | 0.0005 |

higher velocities will doubtlessly keep the scale film to a minimum thickness and temperature.

## Scaling Resistances

In view of the above discussion it is apparent why scaling rates are not usually computed. It also explains why the amount of extra surface to be included in an exchanger above that required for a theoretically clean surface is almost always a matter of judgment or experience on the part of the designer. The use of the transfer rate of the clean exchanger therefore still affords the best means for arriving at the scaling resistance. This method requires the transfer rate to be determined frequently and compared with the rate when new or that obtained directly after each cleaning. Consistent results can be obtained in this manner and there exists such data within the various plants. Naturally, such data do not correlate well since the manner and thoroughness of cleaning will influence the results.

The scale resistance to heat flow occurs upon the inside as well as outside of the heating surface, the summation of the two representing the total scaling resistance. It is this latter value which is commonly used since it is much less convenient to determine the two component parts. The fact should not be overlooked, however, that no amount of cleaning upon one side of the surface can possibly reduce the total scale resistance below that value existing on the uncleaned side.

In order that the open-type cooler or condenser will have sufficient excess tube surface to maintain satisfactory performance in normal operation, with reasonable service time between cleanings, the following minimum inside scale resistances are recommended. For conditions of extreme fouling, or poor maintenance, where experience shows such necessity, higher scale resistances than those listed should be used. Values given are for average temperature and velocity ranges. (See Table 1.)

## Outside Scale Resistance

The extent of fouling to be expected upon the outside surface of open-type coolers and condensers is even more difficult to predict than that for the inside surface. Additional factors entering the problem for this case are the completeness of the spray water distribution over the surface and the degree of spray water evaporation. The scaling is further influenced by the condition of the recirculated spray water, and whether or not the salts which it contains are allowed to concentrate in the cooling-tower basin.

In order to complete the estimation of the total scale resistance, values are given (in Table 2) for the scale resistance upon the exterior surfaces of open-coolers. The data upon which it is based seems to correlate best when referred to the spray concentration employed. In other words, the exterior scale resistance decreases as the spray concentration increases. The present data indicate a variation in this respect as given in Table 2.

## Computation of Open Type Cooler

The use of these various thermal resistances in the design of open-cooler sections probably can be illustrated best with a typical problem subject to slide-rule accuracy. As in most cases of this kind, the solution is one of trial and error, requiring the designer to first make a guess at a cooler which will meet the service requirements. If the surface so selected cannot be verified by the resistance calculations, then other selections must be made until a satisfactory check is obtained.

For the problem at hand, assume a requirement to cool 382 g.p.m. of distilled engine-jacket water from an initial temperature of 143° to a final temperature of 130° F. The cooling spray water is available at a temperature of 73° F. and experience has shown that scaling is not excessive if the temperature is kept at 114° F. or below.

The first step will be to select a possible cooler to render the above service. Such a cooler might be as follows:

Length of tubes exposed to spray water (L), 12.00 ft.
Horizontal width of cooling surface (B), 2.58 ft.
Tube area exposed to spray (LXB), 30.98 sq. ft.
Outside diameter of tubes (D), 1.00 in.
Inside diameter of tubes ($D_i$), 0.902 in.
Horizontal spacing of tubes (P), 0.1562 ft.
Vertical spacing of tubes (V), 0.1094 ft.
Vertical rows of tubes (N), 4.0.

The first trial will be made upon the basis of the

**TABLE 2**

**Minimum Scale Resistances for Spray Water on Exterior Surfaces of Open Type Coolers**

| Spray Concentration (M) lbs./min./sq. ft. | Scale Resistance |
|---|---|
| 5 | 0.00253 |
| 10 | 0.00248 |
| 20 | 0.00240 |
| 30 | 0.00233 |
| 40 | 0.00227 |

spray water striking the cooler surface at 73° F. and leaving at 114° F. This temperature range requires that a guess be made as to the spray water concentration, followed by a calculation check to see if this rate is sufficient in view of the evaporating effect and assumed cooler characteristics. As a trial, a spray concentration of 27.8 pounds per minute per square foot of projected cooler surface will be used. This spray rate in the nomenclature of Figure 1 is (M).

The logarithmic mean temperature difference (T) for the spray water on and off the cooler, 73° and 114° F. respectively, is 92° F. The value of (MT) is now found equal to 27.8 × 92, or 2558, and introducing this value into the curve of Figure 1, $(E)/(DXY)^{0.1}$ is found to have a value of 0.18.

The character factors for the assumed cooler must now be found, still following the nomenclature of Figure 1.

$$D = 1/12 = 0.0833 \text{ ft.}$$

$$X = \frac{P-D}{P} = \frac{0.1562 - 0.0833}{0.1562} = 0.466$$

$$Y = \frac{P-D}{D} = \frac{0.1562 - 0.0833}{0.0833} = 0.874$$

$$DXY = (0.0833)\ (0.466)\ (0.874) = 0.0339$$

$$(DXY)^{0.1} = (0.0339)^{0.1} = 0.7122$$

The value of (E) can now be determined:

$$E = 0.18 \times 0.7122 = 0.128$$

It is now known that 12.8 percent of the total heat removed in the cooler is carried away through evaporation of the spray water.

The total heat to be removed in the cooler can be found by considering the jacket water side as follows:

$$H = 382 \times 60 \times 8.33 \times 0.9843 \times 0.9981\ (143-130) = 2{,}440{,}000 \text{ B.t.u./hr.}$$

The specific gravity and specific heat of the water in the above equation being taken at a temperature of 136.5° F.

The heat appearing as sensible heat in the spray-water can easily be found:

$$(2{,}440{,}000)\ (1.0 - 0.128) = 2{,}128{,}000 \text{ B.t.u./hr.}$$

The final approximate temperature of the spray water leaving the cooler is found in the following manner:

$$2{,}128{,}000 = (27.8)\ (60)\ (30.98)\ (0.9974)\ (t_2 - 73)$$
$$t_2 - 73 = 41.3$$
$$t_2 = 114.3$$

As this value checks the specified spray water temperature of 114° F., the solution can be continued. Had ($t_2$) not closely approximated the temperature of the spray water leaving the cooler, it would have been necessary to repeat the work using other assumed cooler characteristics. For example, the projected area value could be altered until a satisfactory result was obtained.

Now that the temperature rise of the spray water has been verified, it will be in order to establish the value of the film coefficient on the outside of the tube surface. This can be accomplished by the use of Figure 3, following the nomenclature given on this chart.

The value of the hourly spray water concentration can immediately be found:

$$W = \frac{G}{LXB} = \frac{27.8 \times 60 \times 30.98}{12 \times 2.58} = 1666 \text{ lbs./hr./sq. ft.}$$

$$W^{0.8} = (1722)^{0.8} = 9.26$$

Values of D, T, N, X and Y have already been assumed and verified. The viscosity (Z) for the spray water at the temperature (T), is 0.741 centipoises. The value of $(N)^{0.05}$ becomes $(0.1094)^{0.05}$, or, 1.072.

By means of these various values, the factor $(W^{0.8}DXY)/(2.42ZV)$ in Figure 3 is determined. This factor becomes:

$$\frac{W^{0.8}DXY}{2.42ZV} = \frac{(9.26)\ (0.0833)\ (0.466)\ (0.874)}{(2.42)\ (0.741)\ (1.094)} = 1.600$$

Applying this factor to the curve of Figure 3, a value of 1500 is obtained for the expression $h_o/N^{0.05}$. Knowing the value of $N^{0.05}$ permits the ready solution of $h_o$, the outside film coefficient, thus:

$$h_o = 1500 \times 1.072 = 1608 \text{ B.t.u./hr./sq. ft./°F.}$$

The reciprocal of this coefficient, $\left(\frac{1}{h_o}\right)$, or $\left(\frac{1}{1608}\right)$ is the outside film thermal resistance, and is equal to 0.000622.

### Inside Film Coefficient

Attention now can be given to the determination of the inside film coefficient, or that for the distilled water flowing within the tubes. This can be accomplished by the use of Figure 2, wherein the physical properties of the jacket water are taken at the arithmetic mean of the terminal temperatures. In this case, the evaluating temperature is $\frac{143+130}{2}$, or, 136.5° F.

The physical properties of water for this temperature are:

Viscosity, (Z) = 0.4860 Centipoises
Specific heat, (C) = 0.9981 B.t.u./lb.
Specific gravity, (S) = 0.9843 (Density at 40° F. = 1)
Conductivity, (k) = 0.3761 B.t.u./hr./sq. ft./°F./ft.

As an initial assumption, the velocity of the jacket water within the tubes will be taken at 14.75 feet/second. The number of tubes required at this velocity for 382 g.p.m. of jacket water can be obtained in the following manner, each tube having an inside cross-sectional area of 0.638 square inches:

$$\text{Number tubes/pass} = \frac{382 \times 144}{60 \times 7.5 \times 14.75 \times 0.638} = 13$$

The mass velocity through each cooler pass becomes:

$$G = \frac{382 \times 60 \times 8.33 \times 0.9843 \times 144}{13 \times 0.638} = 3{,}260{,}000 \text{ lbs./hr./sq. ft.}$$

Knowing the mass velocity, the factor DG/2.42Z can be found as follows:

$$\frac{DG}{2.42Z} = \frac{(0.0751)\ (3{,}260{,}000)}{(2.42)\ (0.486)} = 208{,}000$$

Inserting this value into the plot of Figure 2, the factor

$$\left(\frac{h_i D}{k}\right) \Big/ \left(\frac{2.42CZ}{k}\right)^{0.4} = 420$$

Solving now for the factor, $\frac{2.42CZ}{k}$, we have,

$$\frac{2.42CZ}{k} = \frac{2.42 \times 0.9981 \times 0.486}{0.3761} = 3.12$$

$$\left(\frac{2.42CZ}{k}\right)^{0.4} = (3.12)^{0.4} = 1.577$$

Substituting this value above, the following equation may be written:

$$\frac{\frac{h.D}{k}}{\left(\frac{2.42CZ}{k}\right)^{0.4}} = \frac{\frac{h_i \times 0.0751}{0.3761}}{1.577} = \frac{0.1996 \times h_i}{1.577} = 420$$

Solving for ($h_i$), the inside film coefficient:

$$h_i = \frac{420 \times 1.577}{0.1996} = 3320$$

Correcting this inside coefficient on the basis of outside surface by means of the ratio of inside to outside tube diameters:

$$h_{i\,(Corrected)} = 3320 \times \frac{0.902}{1.00} = 2990 \text{ B.t.u./hr./sq. ft./°F.}$$

The thermal resistance for flow within the tubes is $\frac{1}{2990}$, or, 0.0003342.

It is now necessary to select the scale resistance for inside and outside the tube surfaces. For distilled water, or the inside scale, the resistance is 0.0001. This value is taken directly from Table 1. The scale resistance on the outside of the tube is likewise obtained from Table 2, by extrapolation for a spray concentration of 27.8 pounds per square foot per minute. This value is found to be 0.00235.

The total resistance to heat flow from the inside to the outside of the tube is the sum of the four component parts as shown in the following:

| | |
|---|---|
| Inside film resistance | = 0.000334 |
| Inside scale resistance | = 0.000100 |
| Outside scale resistance | = 0.002350 |
| Outside film resistance | = 0.000622 |
| Overall thermal resistance | = 0.003406 |

The overall heat transfer coefficient is the reciprocal of the total resistance (R), and is equivalent to:

$$\frac{1}{R} = \frac{1}{0.003406} = 294 \text{ B.t.u./hr./sq. ft./°F.}$$

It is now possible to find the total cooling area required by first determining the logarithmic mean temperature difference for the operating conditions. The jacket water is cooled from 143° to 130° F. while the spray water is heated from 73° to 114° F. The corresponding M.T.D. is 41° F.

From the general heat transfer equation, the total cooling surface required is:

$$A = \frac{2{,}440{,}000}{41 \times 294} = 203 \text{ sq. ft.}$$

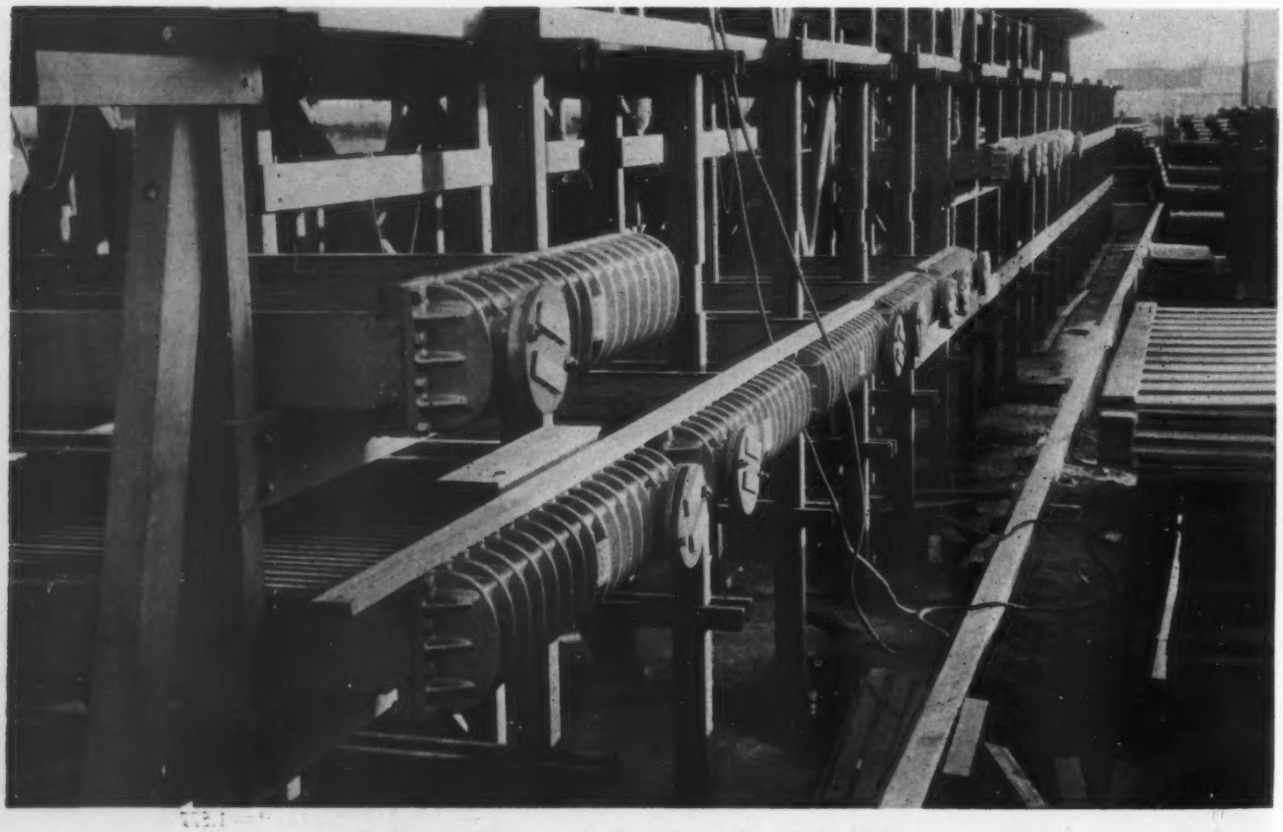
Complying with the initial assumption that the tube length would be 12 feet, the number of 1-inch O.D. Admiralty metal tubes required will be:

$$\frac{203}{12 \times 0.2618} = 65$$

It will be recalled that the solution of the inside film coefficient was based upon 13 tubes per pass, so that the cooler can be arranged for 5-pass flow. If these 65 tubes can be made to fit into the original cooler selection in regard to the dimensions B, P, N and V, the problem is solved. This is the case for this particular problem.

It might be of interest to set forth the spray water required over this cooler. The amount of spray water will be approximately:

$$\frac{27.8 \times 30.98}{8.33} = 103.2 \text{ g.p.m.}$$



**Coolers in Place in Cooling Tower Ready for Piping.**

# High-Tensile Steel For Refinery Service

WELDON L. ARCHER

IN this day of streamlined trains the average citizen is beginning to take high-tensile steels for granted. And well he may. But what about the refiner? Does high-tensile-strength steel offer him any advantages not possessed by the usual mild steel employed in pressure vessels? Definitely, the answer is yes. The modern trend is toward an ever increasing application of this material for refinery pressure vessels.

Before getting too far into this subject it may be well to describe high-tensile-strength steel. There are many such steels on the market under patented names such as Corten, Cromansil, Manten, R. D. S., Silten, Yoloy, Mayari R, HS-1, Carbon-Moly, Jalten, HS-2, Hi-Steel, HT-50, Centralloy, 70-90 and others. Each of these materials offers some special advantage. All of them are high-tensile-strength alloys. None of them, with the recent exception of carbon-moly, may be used in pressure vessels.

So high-tensile-strength steel under the rules of the API-ASME code takes on a definite and distinct meaning. Only that steel meeting the ASTM specifications for A212-39 (until this year known as ASTM A149 and A150) will qualify under the code.

By far the greatest majority of pressure vessels have been constructed from low-carbon steel made to ASTM A70 specifications. Since this steel is well known there is no need for a detailed description of it. Suffice it to say that this material contains little carbon (never more than 0.30 percent) and a moderate amount of manganese (decidedly less than the 0.80 percent maximum that is allowed).

### Small Percentage—Big Gains

On the other hand the high-tensile-strength steel contains more carbon, more manganese and, in addition, silicon. The upper limits for these elements now become for carbon, 0.35 percent; for manganese, 0.90 percent; and for silicon, 0.30 percent. Thus an increase of about 1 percent in minor elements raises the strength of the steel from the minimum of 55,000 psi common to ordinary steel to a minimum of either 65,000 or 70,000 psi for the high-strength steel.

The principal reason for using high-tensile steel is to save money. Many applications have shown that lower freight costs as well as lower fabricating expense have favored the installation of equipment built of high-strength steel. Because this steel is available in two grades: A and B with minimum tensile strengths of 65,000 psi and 70,000 psi respectively, the purchaser must choose one of these two grades. Since the price of either grade is the same, why not pick Grade B with the higher strength and get more for your money. Then specify firebox grade which carries a premium of 5 cents per 100 pounds but which gives value received in extra tests at the mill and a higher design factor under the code.

Of all the elements present in steel, carbon exerts the most influence. In Figure 1 is shown the effect of increasing the amount of carbon in a steel on the tensile strength and elongation. A few points of carbon (a point is 0.01 percent) make a profound difference in the properties of steel. Now all high-strength steel has more carbon than in ordinary low-carbon steel. This carbon has increased the strength of the steel and introduced, at the same time, some fabricating problems.

Both the analysis and physical properties of high-strength steel should be considered. This might be done by quoting the ASTM specifications but more knowledge will be gained from a consideration of some actual analyses and physical tests. Table 1 presents a comparison of actual analyses for ordinary low-carbon and high-strength steels in various thicknesses.

Since abstract things such as the influence of carbon on the strength of steel or the relationship between allowable carbon maximums and actual carbon contents are hard to visualize when presented in tabular form, Figures 2 and 3 present this information in graphical form. The fine cooperation of the the actual carbons run as compared with the allowed steel manufacturers is evident when we see how low

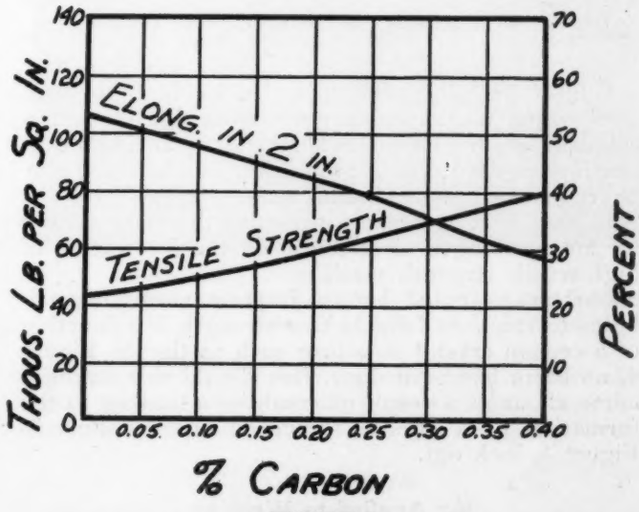



**FIGURE 1**
**Approximate Influence of Carbon on Tensile Strength and Elongation.**

**TABLE 1**
**Analysis of Ordinary and High Tensile Steels for Code Pressure Vessels**

| Tensile Strength | Thickness | Carbon | Manganese | Phos. | Sul. | Sil. |
|---|---|---|---|---|---|---|
| Low | ½" | .16 | .49 | .013 | .027 | .... |
| High | ½" | .25 | .81 | .016 | .027 | .22 |
| Low | 1" | .18 | .54 | .012 | .024 | .... |
| High | 1" | .27 | .66 | .013 | .029 | .20 |
| Low | 1½" | .20 | .51 | .013 | .026 | .... |
| High | 1½" | .26 | .75 | .026 | .039 | .23 |
| Low | 2" | .21 | .49 | .010 | .026 | .... |
| High | 2" | .27 | .80 | .013 | .027 | .22 |
| Low | 2½" | .21 | .49 | .012 | .026 | .... |
| High | 2½" | .26 | .84 | .017 | .036 | .23 |
| Low | 3" | .23 | .51 | .010 | .029 | .... |
| High | 3" | .25 | .75 | .017 | .039 | .24 |

amount of carbon. Attainment of high strength with such lesser quantities of carbon increases the steel makers cost. But the weldability of the steel is improved. Therein lies an extra measure of quality that should be appreciated.

## Physical Properties

Table 2 repeats the steels in Table 1 with regard to the strength and ductility properties. All of these steels represent the firebox, or highest quality, grades.

**TABLE 2**
**Physical Properties of the Low and High Strength Steels Reported in Table 1**

| Tensile Strength | Thickness | Yield Point psi | Ultimate Strength psi | Elongation Percent |
|---|---|---|---|---|
| Low | ½" | 36,670 | 61,210 | 28.8 |
| High | ½" | 48,160 | 79,040 | 26.2 |
| Low | 1" | 36,850 | 63,640 | 25.8 |
| High | 1" | 51,590 | 72,850 | 23.8 |
| Low | 1½" | 36,090 | 61,220 | 26.0 |
| High | 1½" | 49,100 | 78,600 | 26.0 |
| Low | 2" | 35,660 | 62,970 | 27.5 |
| High | 2" | 37,800 | 72,750 | 22.5 |
| Low | 2½"* | 38,860 | 61,450 | 33.2† |
| High | 2½"* | 47,500 | 79,500 | 28.0† |
| Low | 3"* | 40,120 | 64,220 | 34.9† |
| High | 3"* | 48,000 | 76,500 | 29.0† |

* All plates over 2" in thickness were normalized before being tested.
† Elongation reported in two inches, all others in eight inches.

While the physical properties of high-strength steel are important from the standpoint of design calculations, the chemical analysis has an important bearing on the welding properties. For welding may be considered as a simple heat-treating operation. And this heat treatment presents the only excuse for any prolonged dissertation on the fabrication of high-tensile-strength steel.

Carbon, as noted before, imparts strength attributes to steel. As long as this strength is a function of a certain crystal structure such as that in Figure 4, no harm has been done. But should this strength come about as a result of conditions leading to the formation of a crystal structure such as that in Figure 5, look out.

## As Applied to Welding

As the result of some fine fundamental research work carried out by Dr. Bain and his associates, we

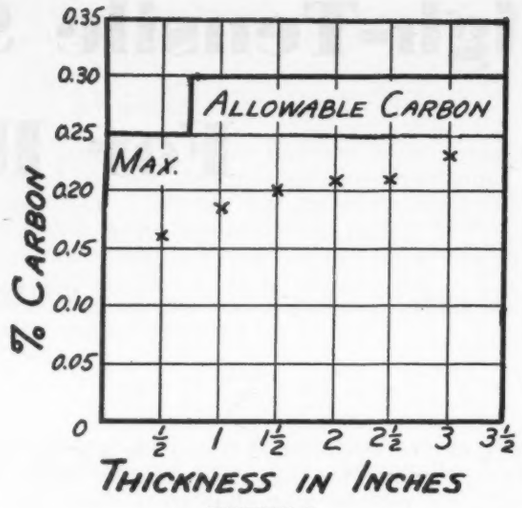



**FIGURE 2**
**Maximum Allowable and Actual Carbons for ASTM A70-39 Firebox Grade.**

are familiar with the interrelationship of time and temperature of transformation in the heat treatment of steel. From the information disclosed in their S-curve it is apparent that transformation takes place at a high temperature of approximately 1100° F. and a low temperature of approximately 200° F. in a very short period. Since the heat treatment that accompanies welding is essentially a short-time reaction, this rapid transformation temperature is extremely important.

Transformation is a new term that would not have been introduced had there been any way to avoid it. The carbon in steel becomes increasingly soluble as the temperature of the steel is raised. When all the available carbon is dissolved a structure known as austentite results. During welding the heat affected zone in the base metal reaches a temperature high enough to dissolve all of the carbon and form austentite. Then the point of welding passes and the heat affected zone cools. In a heavy plate that has not been preheated, cooling caused by the mass quenching action of the surrounding steel may cause the carbon to be trapped in the steel, forming

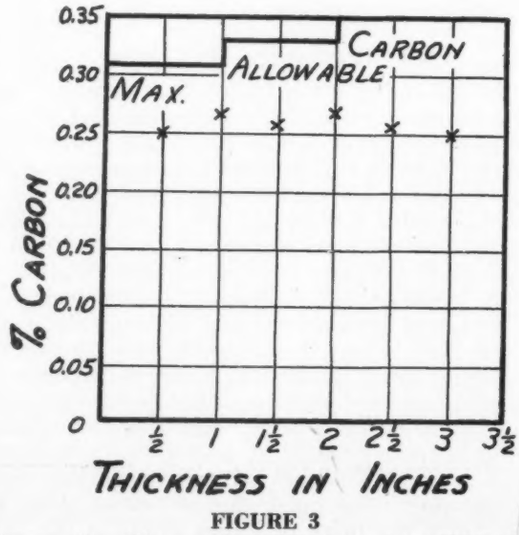



**FIGURE 3**
**Maximum Allowable and Actual Carbons for ASTM A212-39 Firebox Grade.**

a strong but brittle material known as martensite. This would be a low-temperature transformation with the austentite transforming to martensite rather than the more common change such a takes place at the higher temperature.

Usually, as would have happened had this same plate been preheated to 400° F., the transformation

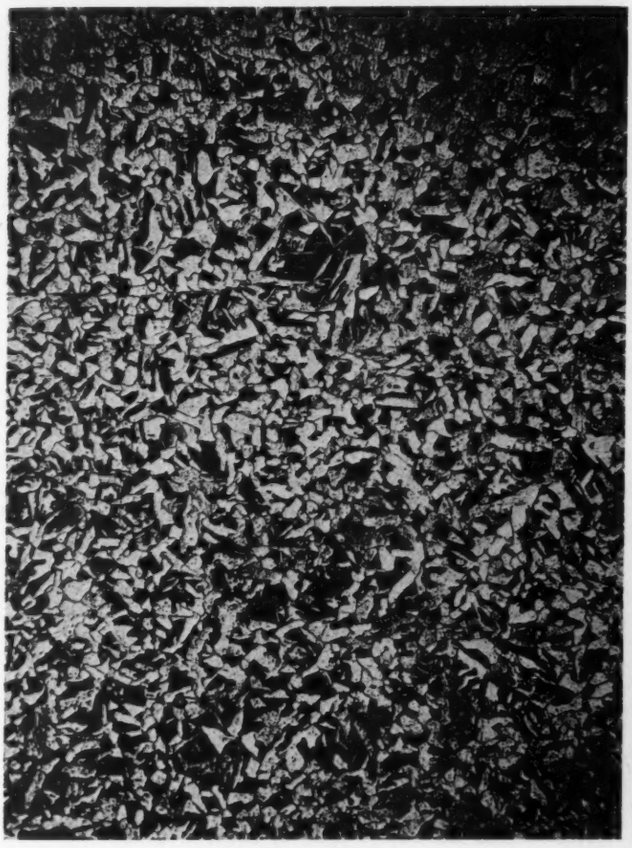


**FIGURE 4**
**Normal Plate Structure in ASTM a212-39 Plate (Magnified 100.)**

from austenite, or the separation of the dissolved carbon, takes place at the higher temperature, 1100° F. Then iron carbide and pure iron combine in a fixed proportion to form pearlite, a strong and ductile state in which weldable steel normally exists. In Figure 4 the pearlite is the dark constituent.

The same thermal cycle is present when low-carbon steel is being welded but the smaller amount of carbon does not invite the harmful structure that becomes possible with increasingly high carbon contents. For that reason preheating of the high-tensile steel is indicated to avoid the formation of a brittle structure.

Pressure vessels fabricated of high-tensile steel are stress relieved as a general rule. The stress-relieving operation constitutes a heat treatment. Very often stress relieving is spoken of as stress-relief annealing. But that term is a harmful misnomer. It is true that thermal stress relieving removes welding stresses that might have reached dangerous proportions. Yet such heat treatment involves neither transformation nor change in crystal structure, both of which take place in a true annealing treatment.

With the exception of preheating to at least 400° F. for any plate thicknesses over ¾-inch there is nothing unusual about the application of high-tensile-strength steel to refinery operations. Of course a welding electrode conforming to the proper strength requirements is indicated. As a general rule carbon-molybdenum electrodes containing 0.40 to 0.60 percent molybdenum such as are used in the welding of carbon-molybdenum steel are specified for the high-tensile material.

### Easy for Skilled Welders

Repairs or changes may be made in exactly the same manner as those for mild-steel vessels which were described previously. Preheating and maintaining a high interpass temperature will lead to perfect welds without any embrittlement of the heat-affected zone whatsoever. Suitable electrodes possess both the strength qualities necessary and, further, the manipulative properties associated with similar mild-steel electrodes thereby enabling any skilled welder to use the low-alloy electrodes without any previous special training.

Since the refinery may be little interested in the welding details associated with high-tensile steel of code quality, the essential item of cost will be dis-

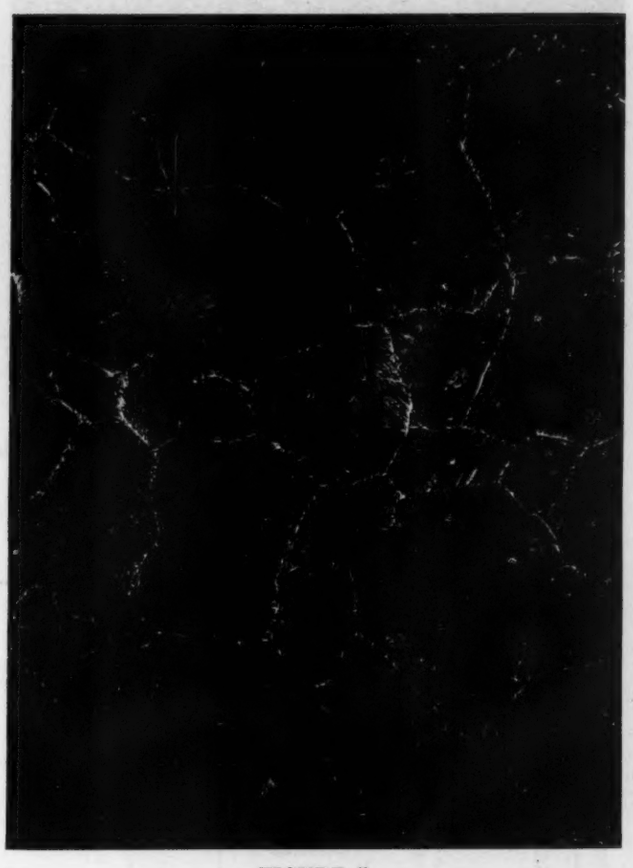


**FIGURE 5**
**Hardened Heat-Affected Zone Near the Top of the Weld. (Magnified 100.)**

cussed in detail. Three important factors enter into any discussion of pressure-vessel cost: material, labor and transportation.

### Comparisons

Because high-tensile-strength steel is stronger than ordinary steel, a vessel made of such material is lighter than a corresponding unit of lower-strength

steel. And in view of additional manufacturing costs in the making of high-tensile steel the cost of the latter is higher. Just how these items compare is demonstrated in Table 3.

At a first glance the figures in Table 3 appear to favor ordinary steel over high tensile. Without considering labor and freight they do. When these other factors are considered, as they are in Table 4, there is no question about the final outcome.

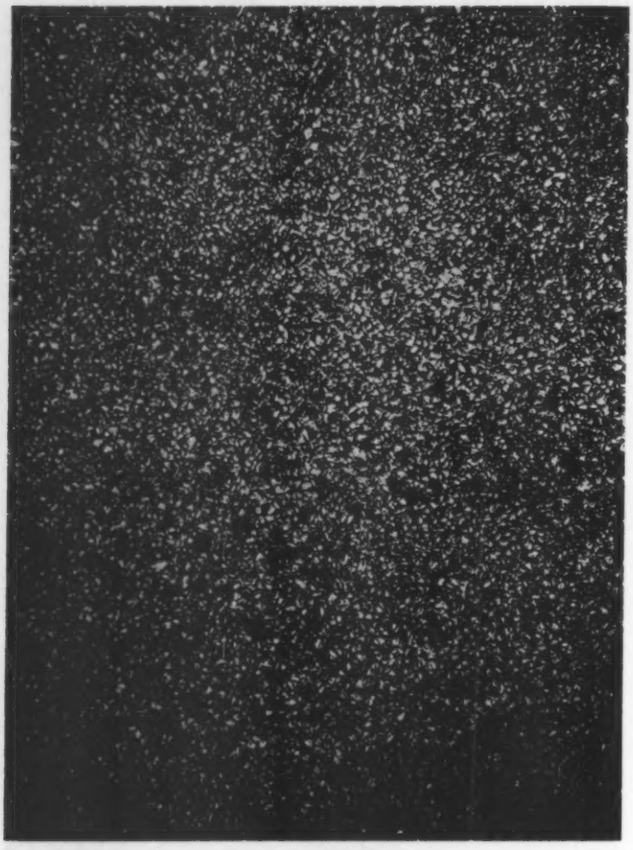


**FIGURE 6**
**Weld Metal in High-Tensile-Strength Plate. (Magnified 100.)**

Needless to say the figures in Table 4 are fictitious although they are representative. The hourly labor rate includes overhead which accounts for what appears to be a high hourly rate. All of these items: material, labor and freight are subject to much modification in different sections of the country. However the trend is right. And whenever vessels become thick and involve a good deal of labor it is important that high-tensile steel be considered if only to the extent of getting an alternate bid involving this metal.

**TABLE 3**
**Comparison of Weights and Material Costs of Ordinary and High Tensile Steel Vessels**

| | Ordinary Steel | High-Tensile Steel |
|---|---|---|
| Weight in pounds | 100,000 | 79,600 |
| Cost, $0.03 and $0.04, respectively | $3,000 | $3,184 |

High-tensile-strength steel will not prove economical for all applications. For instance, joints over one inch in thickness must be radiographed according to the code. Conceivably the cost of radiographing might be such as to prohibit the use of the high-strength material. Instances of that nature have been found.

Then there is the question of corrosion. High-tensile steel corrodes at the same rate as ordinary steel. That means two things: expensive material must be sacrificed for corrosion allowance; and the factor of safety is reduced by corrosion more rapidly than is the case with low-carbon steel of lesser strength.

To make the story complete these last factors have been mentioned although the quantity of ASTM A212 steel being booked by the mills shows a continual increase. It follows that fabricators are forming more and more of this steel into pressure vessels for the refiners. Furthermore truck tanks, tank cars and skid tanks find a natural answer to the question of weight reduction in this material. And late designs are being based upon the use of silicon killed high-tensile-strength steel to make new equipment budgets go a little further.

## Bibliography


American Society for Testing Materials Standards, 1939.

The Alloying Elements in Steel, by Edgar C. Bain.

API-ASME Code, 1938.

Welding Handbook, 1938.

Procedure Handbook of Arc Welding Design and Practice—Sixth Edition.


**TABLE 4**
**Labor and Freight Added to Material Costs of Table 3 to Arrive at Final Cost Figures**

| | Ordinary Steel | High-Tensile Steel |
|---|---|---|
| Material cost | $3,000 | $3,184 |
| Labor-500 man hours @ $2.50 | 1,250 | ..... |
| Labor-406 man hours @ $2.50 | ..... | 1,015 |
| Freight | 500 | 398 |
| Total cost | $4,750 | $4,597 |

# Propane Treating With Caustic Solution

THE propane-butane-straight run gasoline stabilization plant of Cities Service Oil Company at its East Braintree, Massachusetts, refinery was built during the summer of 1938 and was put on the line in August.

There were many considerations which prompted the erection of this plant, among the most important being the demand for liquid propane, the improvement in the straight run gasoline made possible by removal of propane and lighter compounds, the additional recovery of butane for use in gasoline, and the savings in processing costs made possible by splitting the cracked gasoline distillate into light and heavy fractions. The flow through the plant is shown in Figure 1.

The materials processed in the plant come from two combination cracking units with crude charging capacities of approximately 8000 barrels per day each. The charge to the first fractionating tower in the system consists of the cracked gasoline distillate from each combination unit which has been accumulated at a pressure of 134 pounds gage and temperature of 90° F., together with the rich oil from the absorber. Here it is separated into two fractions, the lighter being part of the charge for the depropanizer and the heavier being the heavy end of the cracked gasoline distillate, part of which is used for lean oil on the absorber.

The overhead from the straight run gasoline stabilizer is added to the light fraction from the first fractionating tower, to make up the charge to the depropanizer. The depropanizer makes the cut between propane and butane, that is the butanes and heavier are the bottom product and propane plus the lighter compounds pass overhead.

This overhead makes up the charge to the deethanizer, where it is fractionated into propane as a bottom product, with the lighter compounds passing overhead and going to fuel gas.

### Hydrogen Sulfide Removal

The features delineated above are not new and are mentioned to serve as background for the discussion of the propane treating part of the unit.

The flow of the treater is shown in Figure 2.

Simply stated, the treating consists of contacting the vapors, which make up the feed to the deethanizer, with sodium hydroxide solution, in two steps. The object of the treating is to remove enough hyrogen sulfide, so that the finished propane will meet the specification when tested for hydrogen sulfide by means of the lead acetate method as described in Bureau of Standards Technical Paper No. 41.

The most of the work is done in the treating section in the top of the depropanizer tower. The vapors leaving the fractionating portion of the tower pass

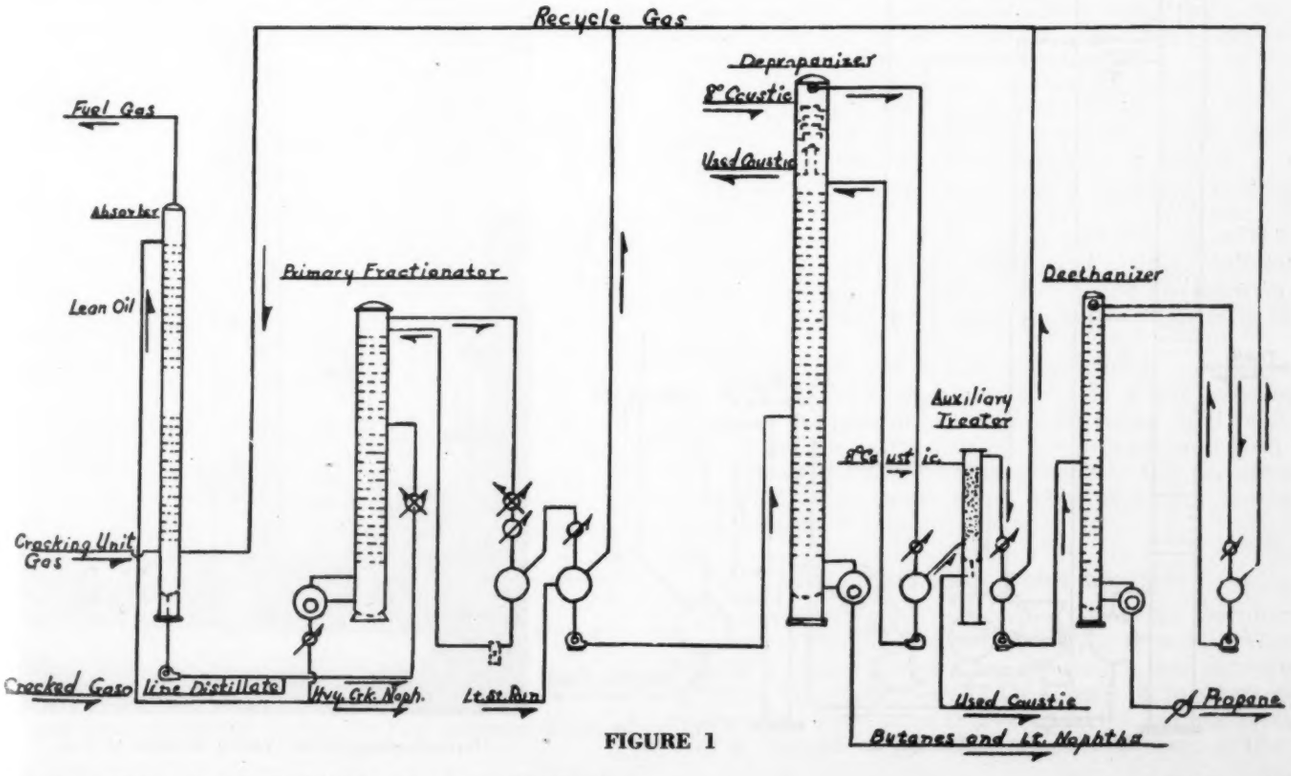



FIGURE 1

up through a chimney into the treating section. This section is 15 feet 9 inches high, with a diameter of 4 feet 6 inches. There is a bottom section 6 feet 6 inches high, in which the used caustic accumulates. Above this are four bubble trays, spaced 1 foot 6 inches apart. The entering caustic flows onto the top tray, down over the remaining three trays, and is released from bottom by a liquid level controller.

Referring to Figure 2 it will be seen that the vapor leaving the treater on the top of the depropanizer passes down through a reflux condenser and into a reflux accumulator. The liquid level in this accumulator is automatically regulated by means of a control valve in the water line to the reflux condenser; that is, only enough heat is taken out in the reflux condenser to supply the required reflux, the remaining vapor passing off the reflux accumulator. The vapors coming from the reflux accumulator subsequently make up the charge to the deethanizer.

An auxiliary treater is located in the vapor line from the reflux accumulator to the final depropanizer cooler. This treater consists of a tower 2 feet by 18 feet, packed with 10 feet of 1½-inch Raschig rings. The vapor passes upward through the tower and the caustic down, accumulating in the bottom, where it is released by means of a liquid-level controller.

There are two 4 feet by 20 feet caustic tanks in the system. The caustic in one tank is being circulated through the treater on top the depropanizer while the caustic in the other tank is being circulated through the auxiliary treater. Each fresh tank of caustic is used on the auxiliary treater first and is circulated through this treater until the caustic in the other tank (which is being circulated through the depropanizer treater) is ready to discard, then both treaters are on the one tank for the few minutes that it takes to drop the spent caustic and recharge with fresh. The auxiliary treater is then put onto the fresh caustic and the cycle repeated.

When these treaters were first put in operation, a series of tests was run to determine optimum operating conditions. Referring to the treater on top the depropanizer, various rates of caustic circulation were tried and best results were obtained at a rate of 1500 gallons per hour, the weirs on all trays being set for maximum submergence. The gravity of caustic solution used was varied from 30° Beaume to 1° Beaume. Caustic solutions between 6 and 8 gravity were found to be the most effective, with heavier solutions much less effective, and lighter solutions only slightly less effective. The caustic solution is carried at a temperature of 125° F., which is slightly hotter than the top of the fractionating section, in order to prevent any condensation of the vapors. The efficiency of the heater is much less affected by changes in the caustic rate than it is by changes in the strength of the caustic solution, small changes in the caustic rate making little difference but if solution is as heavy as 10° Be., efficiency is materially lowered.

The same gravity caustic solution is used on the auxiliary treater, circulating 1000 gallons per hour.

Approximately 65 barrels per hour of reflux are used on the depropanizer and the feed to the deethanizer averages 22 barrels per hour, therefore a total of 87 barrels per hour of material in the vapor form passes through the main treater. The deethanizer feed only passes through the auxiliary treater. There is a total removal of 15 pounds of hydrogen sulfide per hour of which total, about 2 pounds is removed by the auxiliary treater. This corresponds to about 70 percent utilization of the caustic.

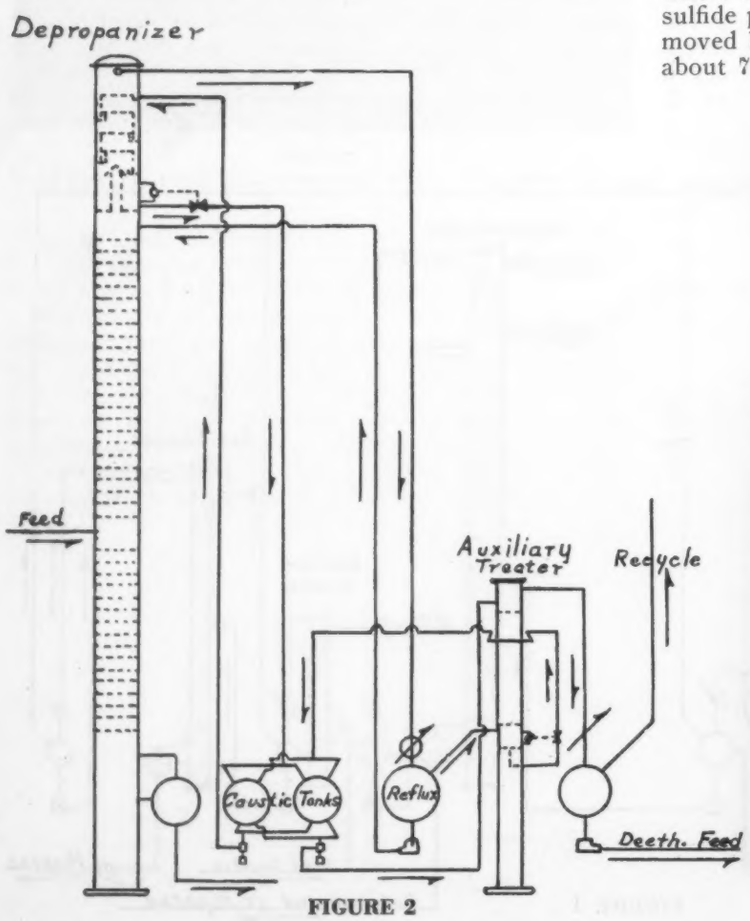
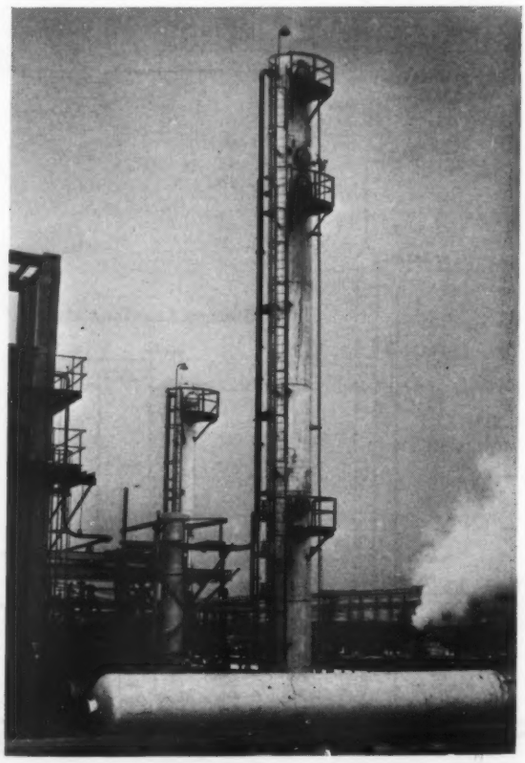



FIGURE 2



Depropanizer With Treater Section at Top.

# Elements of Vaporization and Condensation

## PART IX
## Fractionation of Binary Mixtures

R. L. HUNTINGTON
University of Oklahoma

IN a recent paper of this series[3] it has been shown that the number of theoretical trays required for a given separation of a binary mixture into relatively pure components is controlled largely by the pressure under which the fractionating column operates, i.e., the higher the pressure the greater the number of trays required because of the lowering of the relative volatility of the respective components. Above the retrograde or inversion pressure range, however (from 700 to 1200 pounds per square inch for a number of hydrocarbon mixtures), there is apt to be a reversal in this trend which might cause a reduction in the number of trays for further pressure increases.

### Vapor-Liquid Equilibrium Curves

There are five types of binary mixtures in general which call for fractionation as a practical means of effecting certain separations. Pressure-composition and temperature-composition diagrams[2] serve as tools in presenting the underlying theory or ground work for the fractionation of such mixtures. The y vs x curve which shows the mol fraction of the more volatile constituent in the vapor in its relationship to the mol fraction of the same constituent in the liquid has proven to be the most useful method in attacking the problem of fractionation from a practical standpoint.

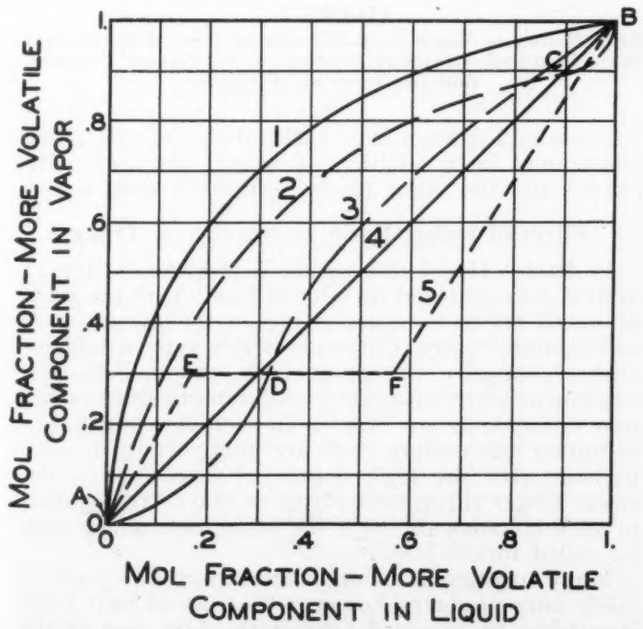



**FIGURE 1**
**Vapor-liquid Equilibria Curves for Five Different Types of Binary Mixtures.**

Let us consider these five types of binary mixtures as shown in Figure 1. Curve 1 represents the mixture in which the components form ideal solutions throughout the entire composition range, and furthermore they have no tendency to associate or to form pseudo-compounds. Mixtures such as butane and pentane or benzol and toluene might be placed in this class. Such mixtures are no doubt the simplest ones to process through fractionators since each component maintains its same relative volatility throughout the height of the tower. The petroleum refining and natural gasoline industries are peculiarly favored in that a major portion of their fractionation and stabilization columns is required to handle mixtures which fall under this particular group or classification.

### Water-Ethanol Fractionation (Curve 2)

The alcohol and liquor distillers were early pioneers in the art of fractionation. Exacting specifications called for the elimination of guess work in the design of their equipment. In fact the petroleum industry turned to the alcohol distillers in order to dispense with much expensive experimentation when it came to realize the advatages of fractionation.

Ethyl alcohol and water form a minimum boiling point whenever the mol fraction of alcohol reaches point C on Curve 2. This means that it is impossible to obtain an overhead product from a single column which is richer in alcohol than point C. Between C and B the vapor is richer in water than it is in alcohol.

Through the use of salt, it is possible to change the relative volatility of alcohol and water in such a way as to manufacture a product richer in alcohol. This is known as the salting out process, and without the application of this principle, the distillers would be forced to use other more expensive means for obtaining the same results.

### Maximum Boiling Point Mixtures

Hydrochloric acid and water have the peculiar property of forming a constant-boiling mixture which boils at a higher temperature than any other mixture of these two compounds. This type of mixture is represented by Curve 3. The constant boiling mixture is located at point D, which expresses graph-

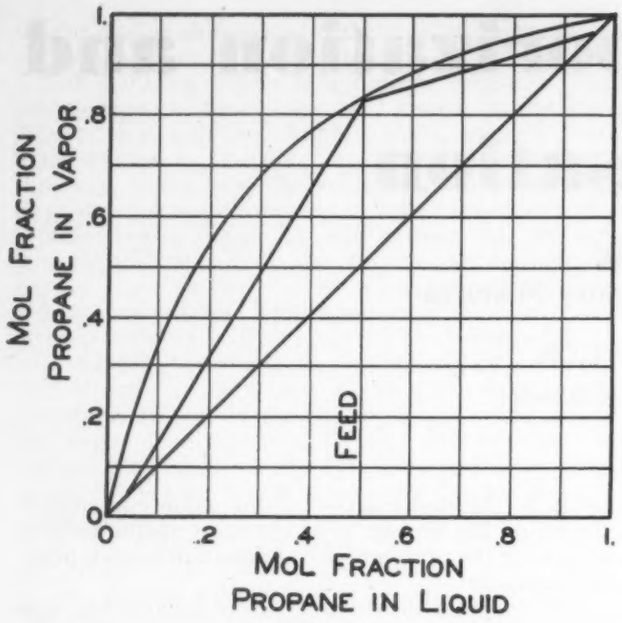



**FIGURE 2**

**Minimum Reflux Ratio-Infinite Number of Trays. Overhead Product = 97 mol Percent Propane. Bottoms = 3 Percent Propane.**

ically the fact that the vapor evolved from liquid has the same composition as the liquid. A further consideration of the significance of this curve reveals that the limits of fractionation for any mixture located between A and D would be a pure component, A representing the less volatile compound and mixture D composed of a certain percentage of acid. Likewise any mixture between D and pure B would have the limits D and B as the maximum degree to which fractionation could be carried out. The addition of some third component such as a salt might change the solubility relationships in such a way that better fractionation could be attained.

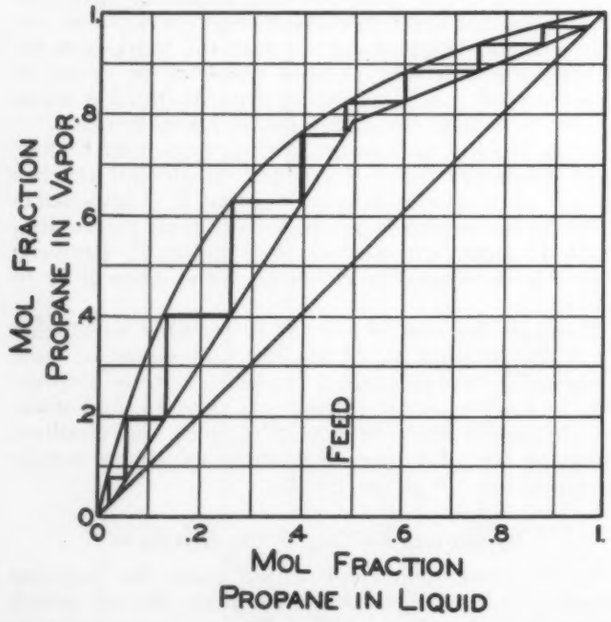



**FIGURE 3**

**Ratio Reflux to Vapor = 0.4 (above feed) 8.8 Theoretical Trays Required. Overhead Product = 97 Percent Propane. Bottoms = 3 Percent Propane.**

### Stereo-isomers

Separation of a mixture of stereo-isomers by fractionation is impossible if the two components making up the system have the same vapor pressures. This type of mixture is represented by Curve 4, which expresses in a graphical manner the fact that the vapor has the same composition as the liquid no matter what percentage of each component is present. Stereo-isomers are compounds which have the same molecular weights and same chemical formulae but exhibit the property of rotating light in different directions. Sugars are illustrious examples of compounds of this type.

### Partially Miscible Liquids

Curve 5 is characteristic of mixtures of this type, such as phenol and water and ether and water. In the composition range from E to F two solutions,

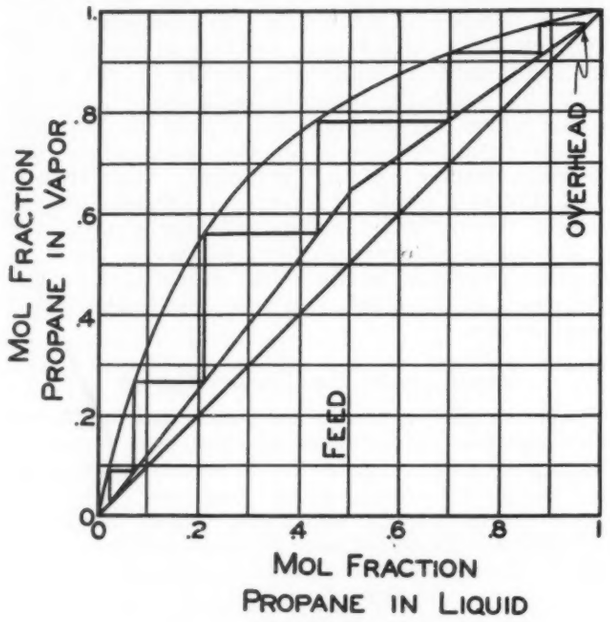



**FIGURE 4**

**Ratio Reflux to Vapor = 0.667 (above feet) 6 Theoretical Trays Required. Overhead Product = 97 Percent Propane. Bottoms 3 Percent Propane.**

separate and distinct from each other, can exist. One phase may be a solution of water saturated with phenol and the other phenol saturated with water.

### Effect of Reflux Ratio on Number of Trays

In Part VIII of this series, a propane N-Butane system was analyzed for a condition where the ratio of liquid reflux to vapor rising in the column was substantially unity. Columns of this type would include laboratory apparatus and certain industrial equipment where relatively small quantities of rather pure compounds are desired. In such cases heat consumption and cooling costs are unimportant in comparison with the high degree of fractionation desired. Fewer theoretical plates or trays are required in such columns to effect the separation which may be called for.

Many commercial columns are expected to produce fairly pure products, however the cost of heat must invariably be balanced against the first cost of the tower. In other words, a column with many trays and a low reflux ratio can effect the same fractiona-

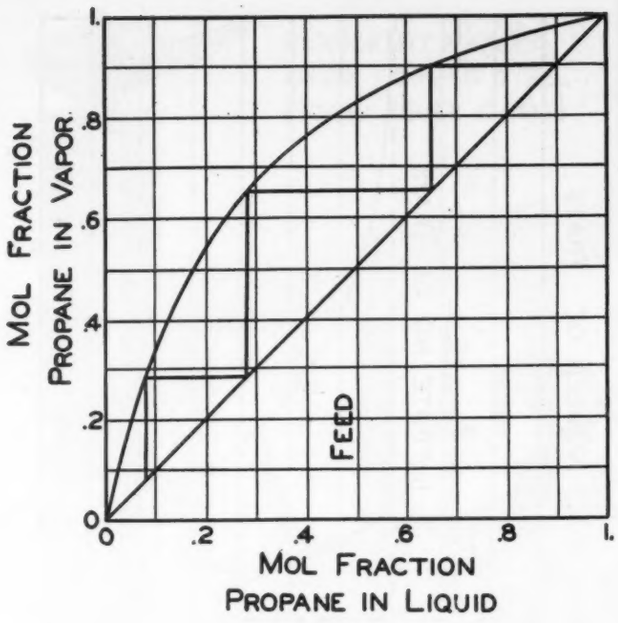



**FIGURE 5**

**Ratio Reflux to Vapor = 1.0. 2.9 Theoretical Plates Required. Overhead Product = 90 mol Percent Propane. Bottoms = 10 Percent Propane.**

tion as a tower having fewer trays and a high reflux ratio. Just which one to choose depends upon the economic balance between these two factors. For example, a cheap supply of fuel and water would be an incentive for the manufacturer to reduce the number of trays in a proposed fractionating tower.

### Minimum Reflux Ratio

In order to accomplish a given degree of fractionation, there is a theoretical minimum reflux ratio below which the desired result cannot be accomplished. Just as the maximum ratio of unity between reflux and vapor is never carried out in actual plant operation, so is the other extreme, the minimum ratio, impractical from an industrial standpoint. With the maximum ratio no production could theoretically be removed from the base or from the top of the tower, while the minimum reflux ratio would require an infinite number of trays.

Such a set of operating lines is shown in Figure 2 for minimum reflux ratio and overhead and bottoms having respectively 97 mol percent and 3 mol percent of the more volatile constituent.

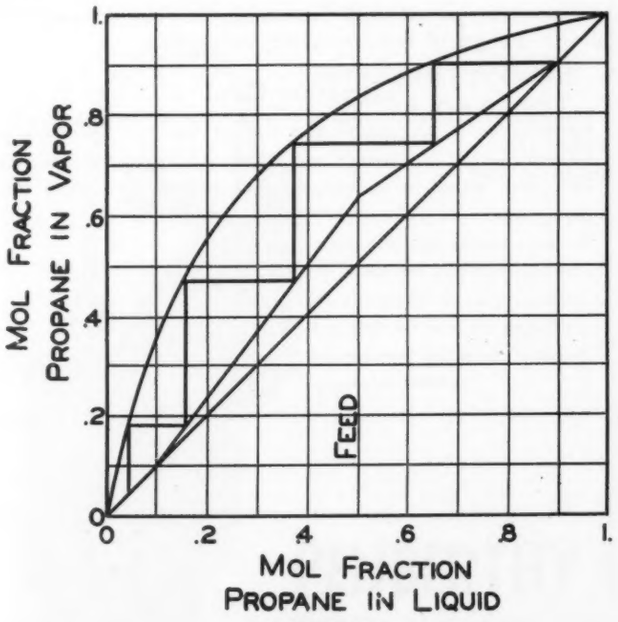



**FIGURE 6**

**Ratio (Reflux to Vapor) = 0.667 (above feed plate). 3.6 Theoretical Plates Required. Overhead Product = 90 mol Percent Propane. Bottoms = 10 mol Percent Propane.**

### Intermediate Reflux Ratios

Commercial fractionators and stabilizers operate with reflux ratios falling between the two extremes which have just been discussed. In Figure 3 it is shown graphically by the McCabe Thiele diagram that 8.8 theoretical plates will be required for a reflux ratio of 0.4. A further increase in this ratio up to

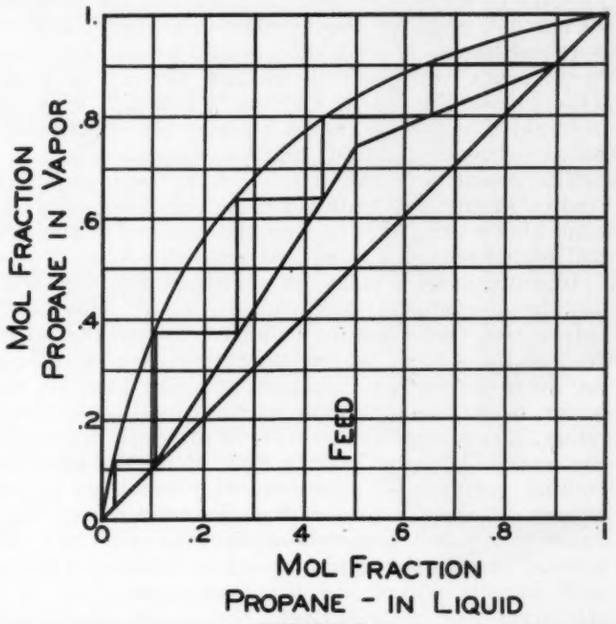



**FIGURE 7**

**Ratio (Reflux to Vapor) = 0.4 (above feed plate). 4.4 Theoretical Plates Required. Overhead Product = 90 mol Percent Propane. Bottoms = 10 mol Percent Propane.**

0.667 (Figure 4) causes the number of plates to be reduced to 6.0, while a reflux ratio of 1.0 (as shown in a previous paper[3] brings the number of theoretical plates down to 4.5. In an actual tower, of course, fractional parts of plates could not be built. It is probable that a larger number of actual trays would be built into a tower than the theoretical number although there are cases where the overall efficiency of a plate may be greater than 100 percent, due to the fact that there is a concentration gradient across the plate. The efficiency at any point in a plate, of course, would be less than 100 percent. The most exact way of measuring the efficiency of a plate is to compare the actual approach toward equilibrium conditions by analyzing the vapor above and below the tray as well as the liquid on the tray. Murphree[4] has expressed the efficiency of a plate as follows:

$$y_n = E_m y_n^* + (1 - E_m)\, y_n - 1$$

in which $y_n^*$ is the vapor in equilibrium with the liquid on plate n, and $E_m$ is the Murphree efficiency factor.

Carey[1] has shown that the efficiency of a plate

can be determined fairly well by measuring the temperature of the vapor above and below the plate as well as the liquid on the plate. He expressed this temperature efficiency as follows:

$$E_T = \frac{T_1 - T_2}{T_1 - T_L} = 1 - \frac{-HS\theta}{e^{McV'}}$$

in which $E_T$ = "temperature efficiency" of the plate.
$T_1$ = temperature of vapor entering plate.
$T_2$ = temperature of vapor leaving plate.
$T_L$ = temperature of liquid on plate.

From an experimental standpoint it would be much easier to determine the efficiency of a tray by taking temperatures rather than that of analyzing the vapor and liquid phases.

If a 50-50 mixture of propane and normal butane is to be given less fractionation so that the overhead product is 90 mol percent propane and the bottoms 10 percent propane, the number of theoretical trays required for such separation would be far less than those needed for making 97 mol percent propane. This is brought out in Figures 5, 6 and 7, where it is found that 2.9, 3.6, and 4.4 plates are required for reflux ratios of 1.0, 0.667 and 0.4, respectively.

The results of these studies have been summarized in Figure 8 in order to show the effect of reflux ratio above the feed plate on the number of theoretical plates required for given separations.

In conclusion, it may be said that the design of any fractionator involves among many other considerations, the economic balance between the initial cost of the tower and the operating cost of providing heat to the feed stream and the base of the tower, as well as a cooling medium for the overhead reflux. The greater the number of plates in the tower, the less will be the heating load in the quantitative cooling medium to condense the overhead vapor stream. It is easy to see that the ratio of reflux to vapor must fall somewhere between the two extremes, namely the minimum reflux ratio for a tower with infinite plates and the maximum ratio for a reflux ratio of unity between the overflowing liquid and the ascending vapor.

In a number of refineries and gasoline plants the reflux ratio is often given as the ratio of the number of parts of reflux to those of overhead production. For example, a reflux ratio of one for overflow to vapor is equivalent to an infinite ratio of reflux to production. A reflux ratio of 2/3 for overflow to vapor would be equivalent to a reflux ratio of 3 to 1 in comparing the overflow to the overhead production.

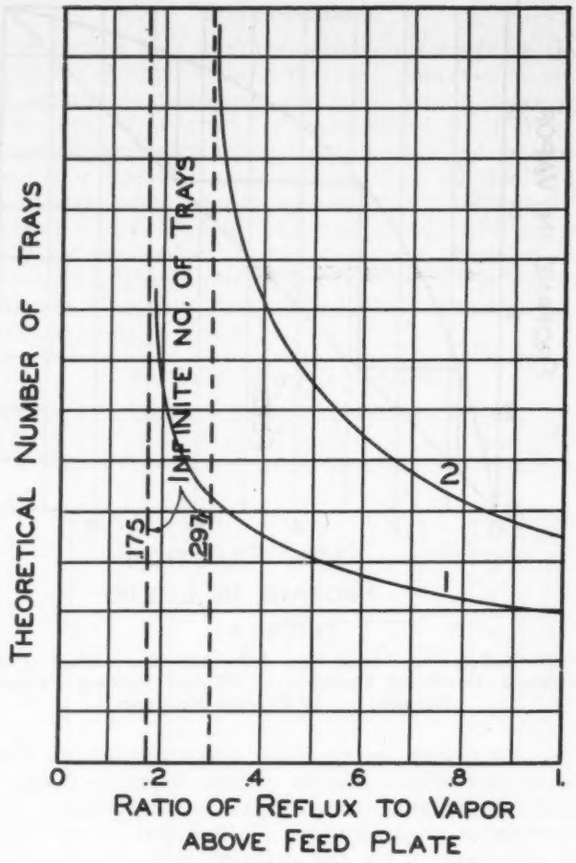


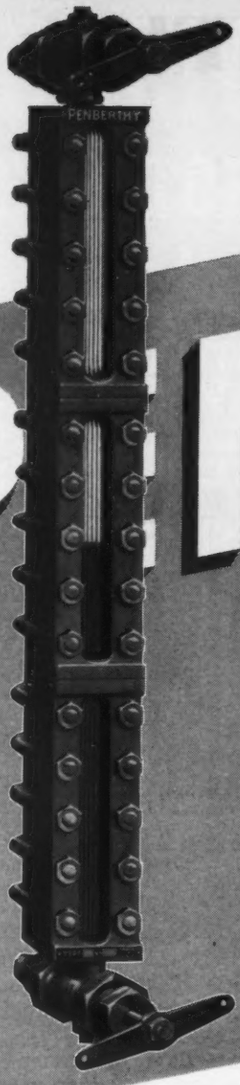

**FIGURE 8**

**Effect of Reflux Ratio on Number of Theoretical Plates. Feed = (50-50) $C_3$ & N $C_4$ Mixture. Curve 1 — Overhead Product 90 Percent $C_3$ Bottoms 10 Percent $C_3$. 2 — Overhead Product 97 Percent $C_3$ Bottoms 3 Percent $C_3$.**

The next paper will deal with further discussions of the design of fractionating columns.

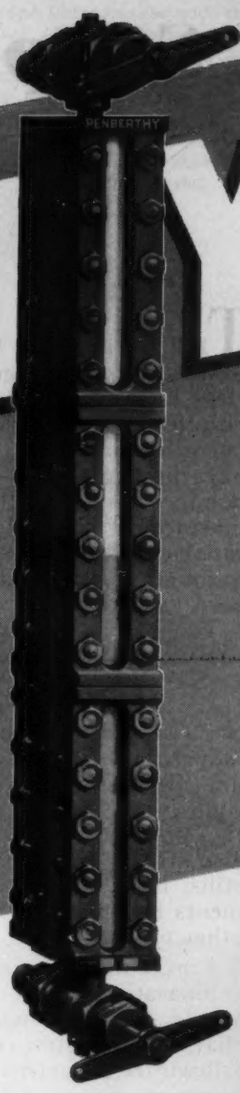
## Literature Cited


[1] Carey, Sc. D. Thesis, Massachusetts Institute of Technology, 1930.
[2] Huntington, R. L., Refiner and Natural Gasoline Manufacturer, August, 1930.
[3] Huntington, R. L., Refiner and Natural Gasoline Manufacturer, September, 1940.
[4] Murphree, Industrial Engineering Chemistry 17, (747) (960) 1925.



**PENBERTHY *Reflex***
**DROP FORGED STEEL**
**LIQUID LEVEL GAGES**

**PENBERTHY**
**DROP FORGED STEEL**
***Transparent***
**LIQUID LEVEL GAGES**



# PENBERTHY LIQUID LEVEL GAGES *meet your requirements*

Liquid shows black—empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.

All Penberthy Gages conform with A. P. I.—A. S. M. E. requirements.

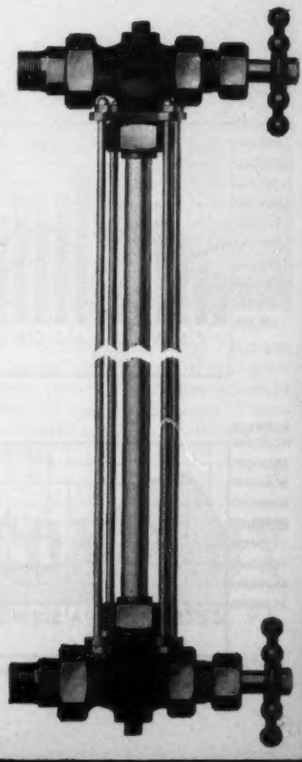
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.

**PENBERTHY *Reflex***
**WATER GAGE SET**

Water shows black—steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

**PENBERTHY**
**DROP FORGED STEEL**
**LIQUID LEVEL GAGES**

Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.



## PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN • Canadian Plant; Windsor, Ontario

PENBERTHY PRODUCTS

# Surplus Gasoline Chief Flaw In Oil Picture

L. J. LOGAN

THE oil industry has continued to hold the advantage of relatively large total demand for its products, despite poor export business; and operations at wells and refineries have been generally upon an economic basis, with the result that inventories currently are mostly satisfactory, with exception of gasoline stocks, which long have been excessive.

The dearth of foreign business and the market-depressing gasoline stocks remain the chief handicaps of the industry; and although there is no remedy for the former, the industry could alleviate the gasoline situation in coming months by rigidly holding down the yield of that product at the refineries, while also strictly limiting crude runs to stills, in line with actual requirements for fuel oils, lubricants, and other products.

Limitation of refinery runs to comparatively low levels likely would be facilitated by the fact that the industry is entering the fall-winter period with a relatively large inventory of heating oil, which may make unnecessary the production of large quantities of surplus gasoline.

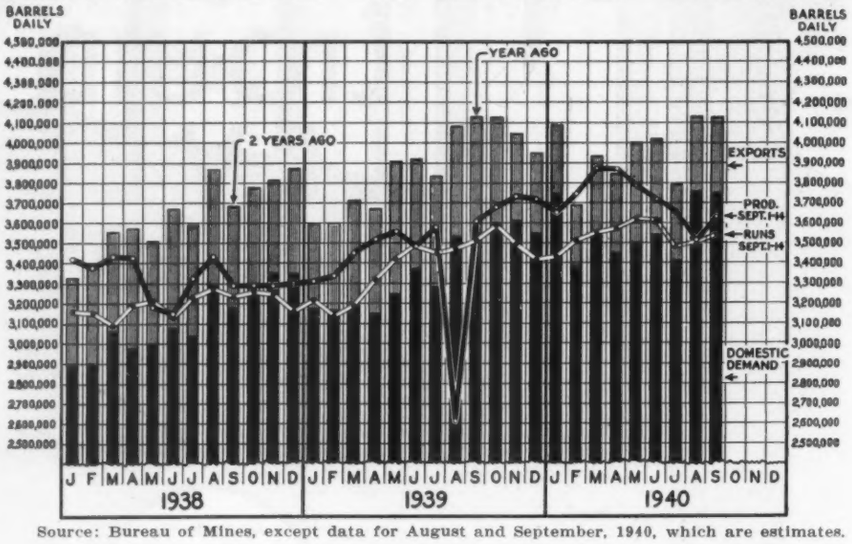
It is generally regarded as likely that domestic demand for gasoline will continue, as heretofore, to show gains of 5 to 6 percent over a year previously, and that exports henceforth may be down 40 to 50 percent, as they have been lately, indicating that total demand may be up around 3 percent. Such a gasoline situation may prevail at least until next spring.

Economists have estimated that even if gasoline demand is comparatively large next spring and summer, it could be efficiently and amply fulfilled without the necessity for more than 85,000,000 barrels in storage at the outset of that heavy-consuming period, that is, on March 31, 1941.

On the assumption that brisk business in heating oils will induce refiners to take subnormal yields of around 43 percent of gasoline from the crude they process, economists have calculated that gasoline stocks could be held down to the 85,000,000-barrel economic level as of March 31 only by restricting crude runs to stills to an average of 3,400,000 barrels daily between September 30, 1940, and March 31, 1941.

Such curtailment of refinery operations appears unlikely, however, in the light of recent trends. Runs to stills jumped 100,000 barrels in the week ended September 21, to near-record proportions of 3,680,000 barrels daily. (The all-time high was 3,690,000 barrels, reached

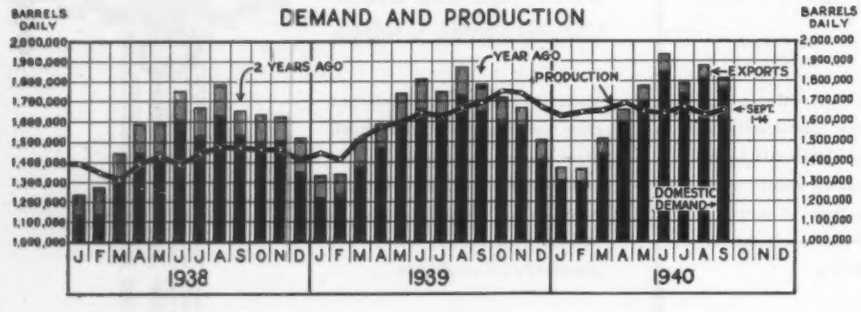
DEMAND FOR ALL U.S. OILS - CRUDE OIL PRODUCTION - REFINERY RUNS


BARRELS DAILY
YEAR AGO
2 YEARS AGO
EXPORTS
PROD. SEPT. 1-14
RUNS SEPT. 1-14
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

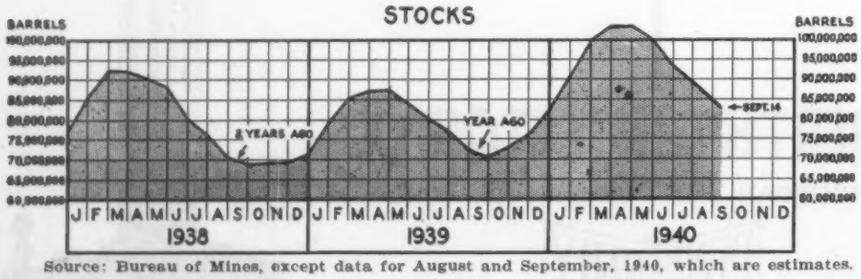
Source: Bureau of Mines, except data for August and September, 1940, which are estimates.

GASOLINE SITUATION

DEMAND AND PRODUCTION

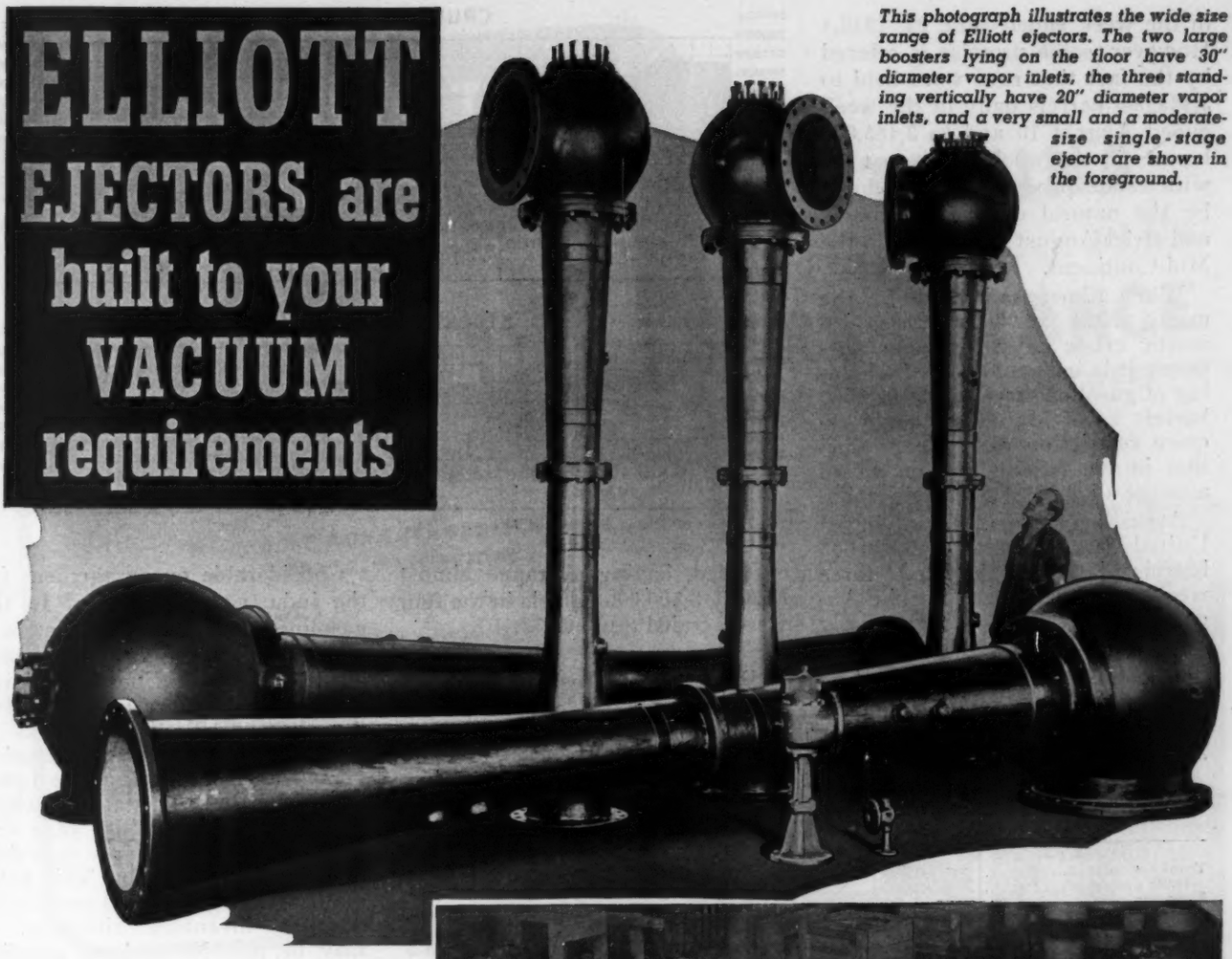

BARRELS DAILY
2 YEARS AGO
YEAR AGO
PRODUCTION
EXPORTS
SEPT. 1-14
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

STOCKS




Source: Bureau of Mines, except data for August and September, 1940, which are estimates.

# ELLIOTT EJECTORS are built to your VACUUM requirements



*This photograph illustrates the wide size range of Elliott ejectors. The two large boosters lying on the floor have 30" diameter vapor inlets, the three standing vertically have 20" diameter vapor inlets, and a very small and a moderate-size single-stage ejector are shown in the foreground.*

*Shipping room photograph of four Elliott four-stage ejectors. These units will maintain an operating pressure of less than 2 mm. absolute on a distillation process. The larger boosters discharge non-condensing into the smaller boosters. These in turn discharge to the barometric condensers, which are served by the two-stage ejectors.*

G-365

**REFINING AND PROCESS** industries know that the best and most economical way to maintain vacuum on units of any size is by means of steam jet ejectors. Elliott ejectors are in use in all such industries. They are designed exactly to the job to be done. Single-stage or multi-stage ejector units are employed, depending upon conditions, such as the vacuum to be maintained, amount of vapor to be handled, temperature and amount of condensing water available, etc.

Our engineers know how to fit Elliott ejectors most efficiently to your processes.

***Write for descriptive bulletin***

## ELLIOTT COMPANY

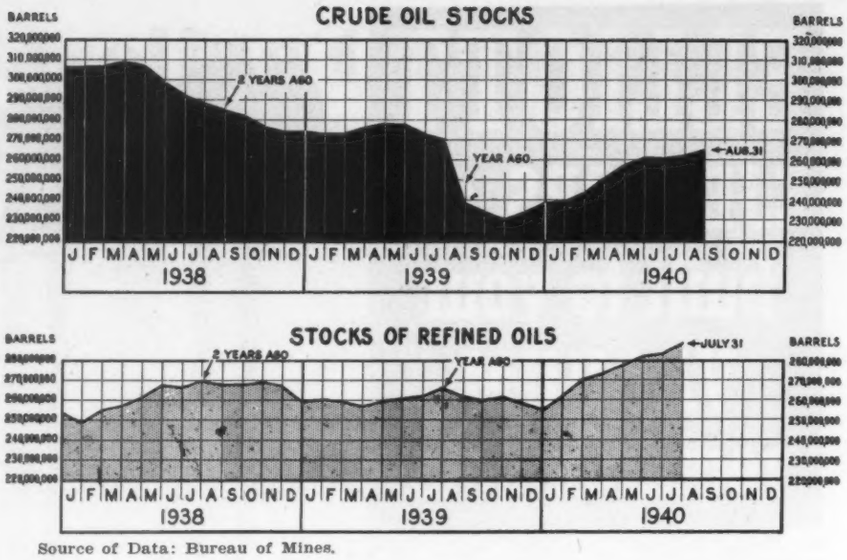
*Heat Transfer Dept.,* **JEANNETTE, PA.**

*District Offices in Principal Cities*

in the week ended June 22, 1940.) However, some promise is offered by the fact that runs were held to 3,435,000 barrels daily in the week ended August 10 and to 3,485,000 barrels in the week of August 24, with crude production held down by the natural decline in Illinois and strict August allowables in the Mid-Continent.

When allowance is made for the use of about 125,000 barrels of domestic crude daily for other purposes, it is indicated that the holding of gasoline stocks to 85,000,000 barrels as of March 31 would require restriction of crude production in the fall and winter to an average of 3,525,000 barrels daily.

Actually, crude production in the United States averaged 3,630,000 barrels daily in the first three weeks of September. But in August, output was more strictly curtailed, having averaged almost exactly 3,500,000 barrels in the four weeks ended August 31.


CRUDE OIL STOCKS
BARRELS
2 YEARS AGO
YEAR AGO
AUG. 31
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940
STOCKS OF REFINED OILS
JULY 31

Source of Data: Bureau of Mines.

## Total Oil Demand Holds Above 1939 Curve Despite Sharply Curtailed Exports

Figures indicate barrels, and are from Bureau of Mines

| | JULY | | | FIRST SEVEN MONTHS | | |
|---|---|---|---|---|---|---|
| | 1939 | 1940 | Percent Change | 1939 | 1940 | Percent Change |
| **SUMMARY—** | | | | | | |
| **Total Demand** | 117,286,000 | 117,702,000 | + 0.4 | 794,162,000 | 830,640,000 | + 4.6 |
| Daily average | 3,783,000 | 3,797,000 | + 0.4 | 3,746,000 | 3,900,000 | + 4.1 |
| **Exports:** | | | | | | |
| Crude petroleum | 7,304,000 | 5,607,000 | — 23.3 | 42,253,000 | 32,022,000 | — 24.2 |
| Refined products | 9,622,000 | 6,219,000 | — 35.4 | 68,505,000 | 49,935,000 | — 27.1 |
| Total exports | 16,926,000 | *11,826,000 | — 30.1 | 110,758,000 | 81,957,000 | — 26.0 |
| **Domestic Demand:** | | | | | | |
| Total domestic demand | 100,360,000 | 105,876,000 | + 5.5 | 683,404,000 | 748,683,000 | + 9.6 |
| Daily average | 3,237,000 | 3,415,000 | + 5.5 | 3,224,000 | 3,515,000 | + 9.0 |
| **TOTAL DEMAND FOR PRODUCTS** | | | | | | |
| **Motor Fuel:** | | | | | | |
| Domestic | 50,508,000 | 53,865,000 | + 6.6 | 308,726,000 | 332,487,000 | + 7.7 |
| Exports | 3,585,000 | 1,686,000† | — 53.0 | 26,980,000 | 14,776,000 | — 45.2 |
| Total | 54,093,000 | 55,551,000 | + 2.7 | 335,706,000 | 347,263,000 | + 3.5 |
| **Aviation Gasoline** (included above): | | | | | | |
| Domestic | ‡ | 689,000 | ..... | ‡ | 3,091,000 | ..... |
| Exports | 266,000 | 210,000 | — 21.0 | 2,872,000 | 2,102,000 | — 26.8 |
| Total | ..... | 899,000 | ..... | ..... | 5,193,000 | ..... |
| **Kerosene:** | | | | | | |
| Domestic | 3,710,000 | 4,257,000 | + 14.8 | 33,772,000 | 39,305,000 | + 16.4 |
| Exports | 774,000 | 227,000 | — 70.7 | 4,499,000 | 2,518,000 | — 44.0 |
| Total | 4,484,000 | 4,484,000 | 0.0 | 38,271,000 | 41,823,000 | + 9.3 |
| **Gas Oils & Distillate Fuels:** | | | | | | |
| Domestic | 6,938,000 | 7,493,000 | + 8.0 | 78,157,000 | 94,300,000 | + 20.6 |
| Exports | 2,857,000 | 1,837,000 | — 35.7 | 18,775,000 | 13,163,000 | — 29.9 |
| Total | 9,795,000 | 9,330,000 | — 4.8 | 96,932,000 | 107,463,000 | + 10.9 |
| **Residual Fuel Oils:** | | | | | | |
| Domestic | 23,442,000 | 23,800,000 | + 1.5 | 179,352,000 | 190,937,000 | + 6.5 |
| Exports | 1,144,000 | 1,387,000 | + 21.2 | 10,521,000 | 9,097,000 | — 13.5 |
| Total | 24,586,000 | 25,187,000 | + 2.4 | 189,873,000 | 200,034,000 | + 5.3 |
| **Lubricants:** | | | | | | |
| Domestic | 1,982,000 | 1,871,000 | — 5.6 | 13,035,000 | 13,677,000 | + 4.9 |
| Exports | 1,022,000 | 741,000 | — 27.5 | 6,280,000 | 7,500,000 | + 19.4 |
| Total | 3,004,000 | 2,612,000 | — 13.1 | 19,315,000 | 21,177,000 | + 9.6 |
| **Wax** (pounds): | | | | | | |
| Domestic | 16,897,000 | 30,333,000 | + 78.6 | 147,919,000 | 177,188,000 | + 19.8 |
| Exports | 16,655,000 | 8,992,000 | — 46.0 | 141,613,000 | 138,798,000 | — 2.0 |
| Total | 33,552,000 | 39,325,000 | + 17.2 | 289,532,000 | 315,986,000 | + 9.2 |
| **Coke** (short tons): | | | | | | |
| Domestic | 90,700 | 120,300 | + 32.4 | 758,900 | 789,700 | + 4.1 |
| Exports | 31,500 | 20,100 | — 36.2 | 148,400 | 137,100 | — 7.6 |
| Total | 122,200 | 140,400 | + 14.9 | 907,300 | 926,800 | + 2.2 |
| **Asphalt** (short tons): | | | | | | |
| Domestic | 554,100 | 658,100 | + 18.8 | 2,472,400 | 2,543,500 | + 2.9 |
| Exports | 3,000 | 25,000§ | ..... | 26,800 | 182,700 | ..... |
| Total | 557,100 | 683,100 | ..... | 2,499,200 | 2,726,200 | ..... |
| **Road Oil:** | | | | | | |
| Domestic | 1,585,000 | 1,629,000 | + 2.8 | 4,338,000 | 4,016,000 | — 7.4 |
| **Miscellaneous:** | | | | | | |
| Domestic | 182,000 | 215,000 | + 18.1 | 1,295,000 | 1,115,000 | — 13.9 |
| Exports | 8,000 | 72,000 | + 800.0 | 56,000 | 696,000 | +1142.0 |
| Total | 190,000 | 287,000 | + 51.0 | 1,351,000 | 1,811,000 | + 34.1 |

* Exclusive of 9,000 barrels exported from non-contiguous territories but inclusive of 850,000 barrels shipped from U. S. to territories. † Includes benzol, 1,000 barrels in July, 1940. ‡ Not available. § Beginning January, 1940, includes both manufactured and unmanufactured asphalt; only unmanufactured asphalt being previously shown.

Considerable encouragement for the industry, with regard to the gasoline and fuel oil situations, was embodied in the lately issued report of the Bureau of Mines forecasting demand for October and discussing the current situation. "Stocks of distillate fuel oil have reached a point 7 million barrels above a year ago," the bureau stated, "which indicates the possibility of a further curtailment in crude runs during the winter months. This automatically would help to correct the gasoline inventory situation. It may be possible to keep gasoline stocks at a practically stationary level during the last quarter of 1940 as compared with the abnormal increase of almost 12 million barrels in the same period of 1939." (The gasoline inventory totaled 82,960,000 barrels on September 21.) The bureau previously had pointed out that the fuel-oil situation had become easier, due to a smaller increase in domestic demand than was anticipated and to the expectation of decreased exports and larger imports.

No material change in the current trend of petroleum demand is at present within sight. The most recent estimate was that of the Bureau of Mines, forecasting that domestic motor-fuel demand would be 7 percent larger in October, 1940, than in October, 1939. At the same time, the bureau stated that forecasts of the principal shippers indicated relatively low gasoline exports again for October, and that the agency estimated exports at 1,600,000 barrels, the same as for September but less than half the actual of October, 1939. These forecasts indicated that total demand for gasoline would be 1,470,000

# NI-RESIST* NICKEL CORROSION-RESISTING CAST IRON

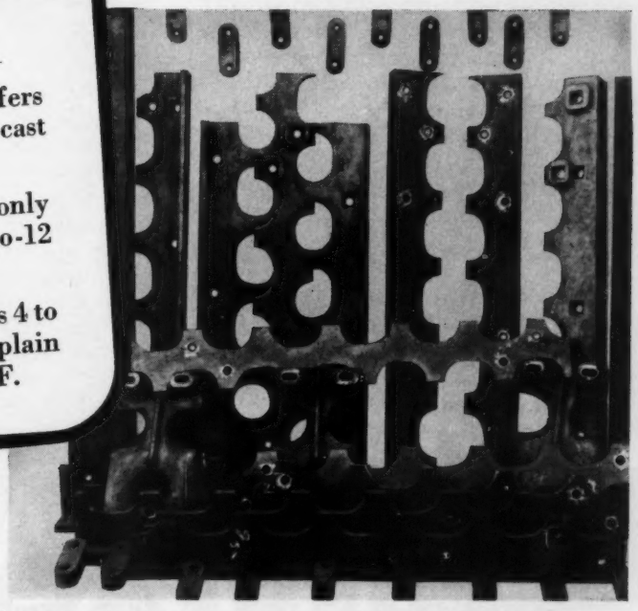
## STAMINA *up to 1300° F. . . PLUS* RESISTANCE *to refinery corrosives*

***NI-RESIST ADVANTAGES FOR REFINERY APPLICATIONS:***

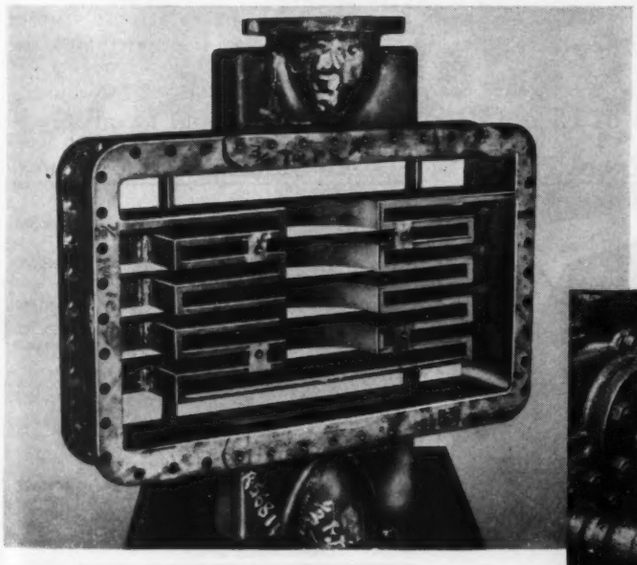
**CRUDE OIL VAPORS AT 760°F....** Ni-Resist offers 3.7-to-1 service ratio over unalloyed grey cast iron in high temperature corrosive vapors.

**GROWTH IN 900°F. STEAM...** Ni-Resist grows only 0.00045" per 1000 hours, growing about 1-to-12 as compared with unalloyed grey cast iron.

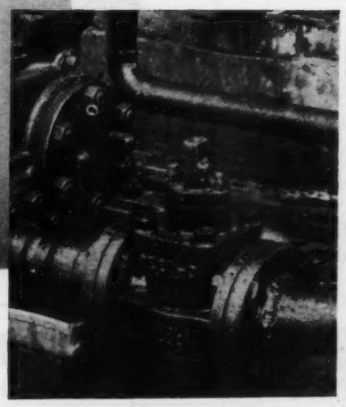
**RESISTANCE TO SCALING...** Ni-Resist provides 4 to 10 times greater resistance to scaling than plain cast iron in oxidizing atmosphere at 1500° F.



**TUBE SUPPORTS** cast in Ni-Resist by Hillis & Sons, Ltd., Nova Scotia for Imperial Oil, Limited, Canada.



**GAS COOLER HEAD** cast in Ni-Resist by Atlantic Foundry Co., Akron, for Griscom-Russell Co., New York, N. Y.



**CORROSIVE SERVICES—** The Valve Division of the Reed Roller Bit Co., Houston, Texas, recommends using non-magnetic corrosion-resistant Ni-Resist in Reed valves which control brine, acids, caustics, chemicals, sludges or other corrosives harmful to plain cast irons.

*Ni-Resist—Reg. U. S. Pat. Off. by The International Nickel Company, Inc.—#278,180.

**For quick, practical answers to your metal problems, please address:**

**THE INTERNATIONAL NICKEL COMPANY, INC.** **67 WALL STREET NEW YORK, N. Y.**

barrels, or 2.8 percent, greater in October, 1940, than in October, 1939.

They also indicated that the total demand for United States oils should be about the same in October of this year as in October of last year, despite sharply lower exports. For the estimates of gasoline demand in October, both domestic and foreign, are practically the same percentage above a year ago as were the actual requirements in July, latest month for which figures are available; and in that month, total demand for all oils was 0.4 percent above a year previously, with total domestic demand up 5.5 percent and total exports down 30 percent. Crude oil shipments in July were off 23 percent and exports of refined products in the aggregate were down 35 percent.

The Bureau of Mines has estimated that exports of crude oil will amount to 3,900,000 barrels in October, the same as the quantity forecast for September but 3,000,000 barrels less than the 6,947,000 barrels shipped out in October, 1939.

The trend of demand has been generally the same for the various refined products: relatively good in so far as domestic use is concerned, but unfavorable with respect to shipments abroad. The total demand for gasoline was up 2.7 percent in July, with domestic consumption 6.6 percent greater than in July, 1939, and with exports off 53 percent. Total demand for kerosene was the same as a year previously, with domestic use 14.8 percent greater but exports down 70.7 percent. Light fuel oils showed a net decrease of 4.8 percent, as an 8 percent gain in domestic use was outweighed by a 35.7 percent curtailment of exports. Heavy fuel oils were required in 2.4 percent larger quantity, as there were gains of 1.5 percent for domestic demand and 21.2 percent in exports. Total demand for lubricants was down 13.1 percent, in reflection of decreases of 5.6 percent in domestic use and 27.5 percent in shipments to other countries.

Because of the relatively higher trends of demand, export and do-

## Changes From Year Ago in Stocks of Crude and Refined Oils in the United States

(Figures indicate barrels)

**LATEST WEEKLY DATA**

(Sources: Crude stocks, Bureau of Mines; all other figures American Petroleum Institute.)

| STOCKS OF: | September 21, 1939 | September 21, 1940 | Percent Change |
|---|---|---|---|
| Gasoline | 71,395,000 | 82,960,000 | +16.2 |
| Gas Oil & Distillate | 37,984,000 | 47,163,000 | +24.2 |
| Residual Fuel Oil | 114,588,000 | 108,191,000 | — 5.6 |
| Crude Oil | [1]233,016,000 | [2]262,475,000 | —12.6 |

**LATEST MONTHLY DATA**

(Source: Bureau of Mines.)

| ITEM | Stocks at End of July 1939 | 1940 | Percent Change |
|---|---|---|---|
| **SUMMARY—** | | | |
| **Crude Petroleum:** | | | |
| Refinable in U.S. | 270,570,000 | 263,498,000 | — 2.6 |
| Heavy in California | 14,375,000 | 13,204,000 | — 8.1 |
| **Natural Gasoline** | 7,123,000 | 7,584,000 | + 6.5 |
| **Refined Products** | 279,380,000 | 289,071,000 | + 3.5 |
| Total, all oils | 571,448,000 | 573,357,000 | + 0.3 |
| Day's supply: | | | |
| July Basis | 151 | 151 | 0.0 |
| 7 Months Basis | 153 | 147 | — 3.9 |
| **PRODUCTS—** | | | |
| Gasoline: | | | |
| Finished | 71,824,000 | 82,025,000 | +14.2 |
| Unfinished | 6,019,000 | 7,040,000 | +16.9 |
| Total | 77,843,000 | 89,065,000 | +14.4 |
| Aviation Gasoline (included above) | [3] | 4,099,000 | ..... |
| Kerosene | 8,855,000 | 8,191,000 | — 7.5 |
| [4]Gas Oil & Distillate Fuels | 27,581,000 | 30,134,000 | + 9.3 |
| [4]Residual Fuel Oils | 96,305,000 | 86,255,000 | —10.4 |
| Lubricants | 7,179,000 | 8,573,000 | +19.4 |
| Wax (pounds) | 109,322,000 | 113,978,000 | + 4.3 |
| Coke (short tons) | 733,000 | 678,000 | — 7.5 |
| Asphalt (short tons) | 596,000 | 623,000 | + 4.5 |
| Road Oil | 1,085,000 | 1,077,000 | — 0.7 |
| Miscellaneous | 285,000 | 417,000 | +46.3 |
| Other Unfinished Oils | 40,296,000 | 42,083,000 | + 4.4 |

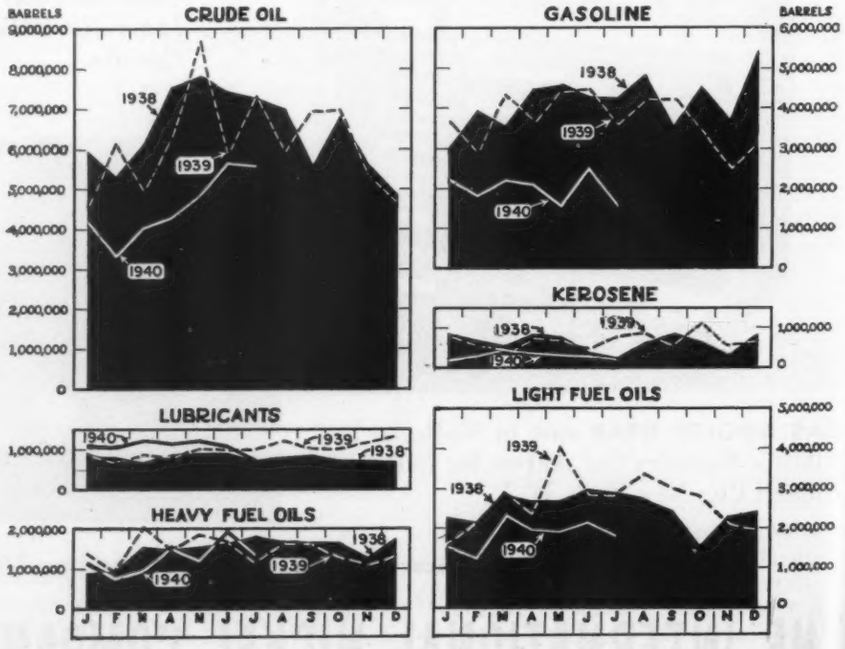
[1] Stocks, September 16, 1939.
[2] Stocks, September 14, 1940.
[3] Not available.
[4] At refineries only

## Oil Exports Down 17 Percent in First 11 Months of War, and Off 30 Percent in July

| ITEM | ELEVEN MONTHS PERIOD Ended July 31, 1939 | Ended July 31, 1940 | Percent Change | MONTH OF JULY 1939 | 1940 | Percent Change |
|---|---|---|---|---|---|---|
| **Crude Oil** | 65,095,000 | 55,877,000 | — 14.2 | 7,304,000 | 5,607,000 | — 23.3 |
| **Products:** | | | | | | |
| Motor fuel | 44,155,000 | 28,147,000 | — 36.2 | 3,585,000 | [6]1,686,000 | — 53.0 |
| Aviation gasoline (included above) | [1]2,872,000 | [2]3,035,000 | + 5.7 | 266,000 | 210,000 | — 21.0 |
| Kerosene | 7,127,000 | 5,221,000 | — 26.7 | 774,000 | 227,000 | — 70.7 |
| Gas oil and distillate | 27,460,000 | 23,048,000 | — 16.1 | 2,857,000 | 1,837,000 | — 35.7 |
| Residual fuel oil | 16,851,000 | 14,453,000 | — 14.5 | 1,144,000 | 1,387,000 | + 21.2 |
| Lubricants | 9,222,000 | 11,997,000 | + 30.1 | 1,022,000 | 741,000 | — 27.5 |
| Wax (pounds) | 226,535,000 | 215,176,000 | — 5.0 | 16,655,000 | 8,992,000 | — 46.0 |
| Coke (short tons) | 223,000 | 235,000 | + 5.4 | 31,500 | 20,100 | — 36.2 |
| Asphalt (short tons) | 44,900 | [3]495,200 | ..... | 3,000 | 25,000 | ..... |
| Miscellaneous oils | 95,000 | 759,000 | + 700.0 | 8,000 | 72,000 | + 800.0 |
| [4]Total Refined Products | 106,101,000 | 86,417,000 | — 18.6 | 9,622,000 | 6,219,000 | — 35.4 |
| Total Crude and Products | 171,196,000 | 142,294,000 | — 16.9 | 16,926,000 | [5]11,826,000 | — 30.1 |

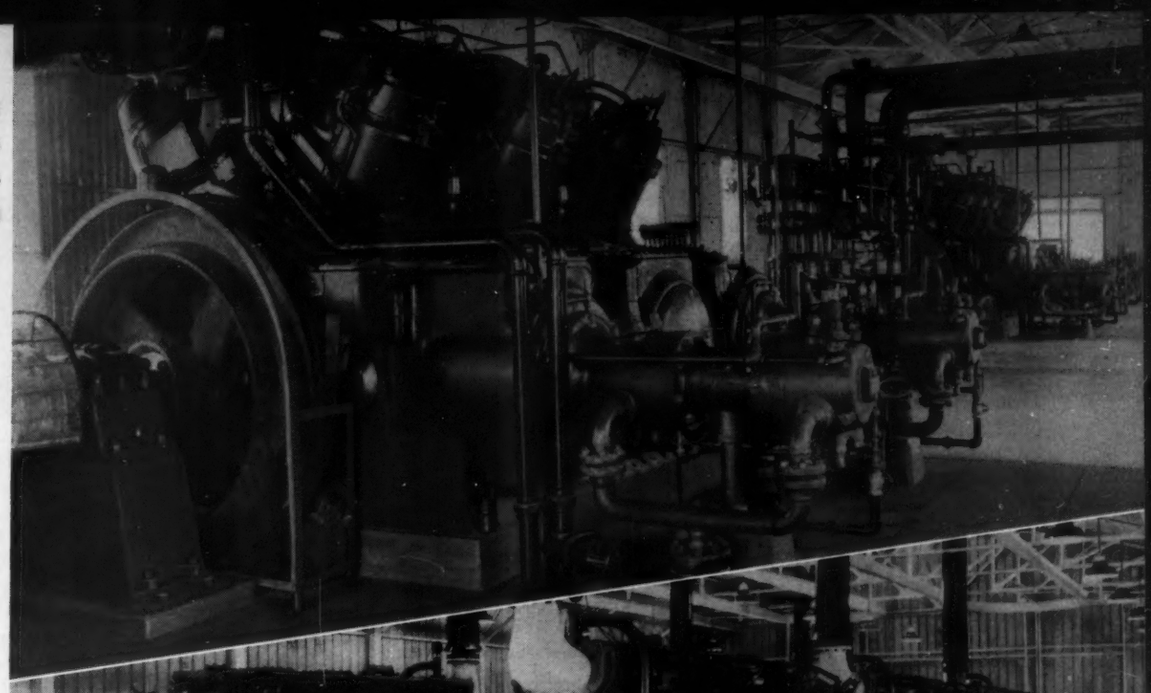
[1] September, October, November, 1938, not included. [2] September, 1939, not included. [3] Beginning January, 1940, includes both manufactured and unmanufactured asphalt; only unmanufactured asphalt being previously shown. [4] Not the sum of the above figures, some of which do not indicate barrels. [5] Exclusive of 9,000 barrels exported from non-contiguous territories, but inclusive of 850,000 barrels shipped from U. S. territories. [6] Includes benzol, 1,000 barrels in July, 1940.

## U. S. Exports of Crude Petroleum and Refined Products




Source of Data: Bureau of Mines.

Type G-MV, 400 and 600-hp compressors at Tide Water-Seaboard's Cayuga No. 2 recycling plant.



# WHY SO MANY GM V ANGLE'S IN RECYCLING?

Type G-MV units in the pressure-maintenance plant of Abercrombie-Harrison companies at Sweeny, Texas

## *Because . . .*

- **More Power In Less Space . . .** "V" power cylinders give double horsepower over straight "angle" type units. V-angle design saves housing and foundation costs.
- **Husky, for the Toughest Jobs . . .** G-MV combines ruggedness with compactness. Meehanite Metal for all iron cast parts. Oversize crankshaft. Oversize bearings . . . two between each throw.
- **Silent-Scot Fuel Injection . . .** Quiet and thrifty! No raising or lowering of valves to regulate fuel flow. No clatter. Equal load distribution among cylinders. Quantity of fuel automatically governed.
- **Easy to Transport and Install . . .** Shipped by rail or truck, completely assembled except for attaching compressor cylinders. Quickly installed and put into service.
- **Streamlined Scavenging . . .** Scavenging air furnished by separate scavenging pistons for each crankthrow. A steady . . . not intermittent . . . flow of fresh air directed scientifically into cylinders.
- **Oil-Cooled Pistons . . .** for lower piston temperatures, reduced cylinder-to-piston clearance, less wear, improved lubrication and elimination of "stuck" rings.

**There's a new G-MV catalog just coming off the presses . . . giving complete details. Write for your copy.**

## THE COOPER-BESSEMER CORPORATION

Mount Vernon, Ohio — PLANTS — Grove City, Pennsylvania

West 43rd St., New York City
estment Bldg., Washington, D. C.
640 E. 61st St., Los Angeles, Calif.
201 East 1st St., Tulsa, Okla.
631 Spring St., Shreveport, La.
Box 1856, Pampa, Texas
Box 454, Greggton, Texas
Magnolia Bldg., Dallas, Texas
529 M & M Building, Houston, Texas
1501 Arcade Building, St. Louis, Missouri

mestic, in the earlier months of this year, as compared with more recent months, figures for the first 7 months were better than those for July. Total demand for United States oils in the first 7 months of 1940 was 4.6 percent (36,000,000 barrels) larger than that in the corresponding months of 1939. Domestic demand was up 9.6 percent, and total exports were down 26 percent, with crude shipments off 24.2 percent and refined product exports down 27.1 percent.

For the 7 months, total demand for gasoline was up 3.5 percent, with domestic use 7.7 percent larger and exports off 45.2 percent. A 9.3 percent gain for kerosene demand resulted from a 16.4 percent increase in domestic demand and a 44 percent decrease in foreign shipments. Light fuel oils showed a 10.9 percent increase in total demand, as a 20.6 percent gain in domestic consumption more than compensated for the 29.9 percent decrease in exports. Heavy fuel oils were used in 5.3 percent larger quantity, as home consumption was up 6.5 percent, while exports were off 13.5 percent. Lubricants showed a 9.6 percent gain for the 7 months, with domestic use 4.9 percent higher and exports 19.4 percent greater.

The effect of the European war on the oil industry of the United States is reflected in an accompanying table, in which shipments are shown for the first 11 months of the war and for July, in comparison with corresponding periods a year earlier.

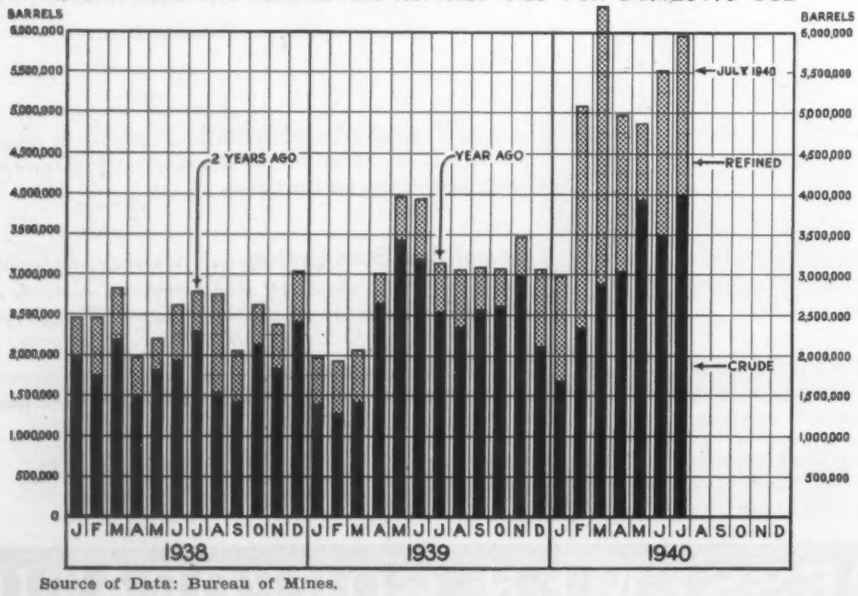
In the first 11 months of the war, all exports of crude and refined oils totaled 142,294,000 barrels, which was 29,000,000 barrels, or 17 percent less than shipments in the like months a year before. Exports of crude, having totaled 55,877,000 barrels, were off 9,000,000 barrels, or 14 percent. Shipments of refined products in the aggregate, having amounted to 86,417,000 barrels, were down 10,000,000 barrels, or 18.6 percent. Gasoline exports were down 6,000,000 barrels, or 36 percent, from 44,155,000 to 28,147,000 barrels. Kerosene shipments were off 2,000,000 barrels, or 26.7 percent, from 7,127,000 to 5,221,000 barrels. Exports of light fuel oils were down 4,500,000 barrels, or 16 percent, from 27,460,000 to 23,048,000 barrels. Heavy fuel oils showed a decrease of 3,500,000 barrels, or 14.5 percent, from 16,851,000 to 14,453,000 barrels. Lubricants were the only major product shipped out in larger quantity than before the war started, exports in the 11 months having totaled 11,997,000 barrels, which amount was 2,775,000 barrels, or 30 percent, greater than that of 9,222,000 barrels for the corresponding months a year earlier.

## Oil Imports for Domestic Use Up Sharply

Figures indicate barrels and are from Bureau of Mines.

| MONTH | Crude Oil | Refined Products | Total |
|---|---|---|---|
| **January:** | | | |
| Jan., 1939.... | 1,373,000 | 609,000 | 1,982,000 |
| Jan., 1940.... | 1,664,000 | 1,321,000 | 2,985,000 |
| Percent Change. | +21.2 | +117.1 | +52.0 |
| **February:** | | | |
| Feb., 1939.... | 1,266,000 | 654,000 | 1,920,000 |
| Feb., 1940.... | 2,343,000 | 2,731,000 | 5,074,000 |
| Percent Change. | +85.0 | +320.0 | +164.0 |
| **March:** | | | |
| Mar., 1939... | 1,404,000 | 659,000 | 2,063,000 |
| Mar., 1940... | 2,895,000 | 3,410,000 | 6,305,000 |
| Percent Change. | +106.2 | +417.4 | +205.6 |
| **April:** | | | |
| April, 1939... | 2,648,000 | 366,000 | 3,014,000 |
| April, 1940... | 3,041,000 | 1,948,000 | 4,989,000 |
| Percent Change. | +14.8 | +432.0 | +65.5 |
| **May:** | | | |
| May, 1939... | 3,434,000 | 529,000 | 3,963,000 |
| May, 1940... | 3,921,000 | 934,000 | 4,855,000 |
| Percent Change. | +14.2 | +76.5 | +22.5 |
| **June:** | | | |
| June, 1939... | 3,196,000 | 750,000 | 3,946,000 |
| June, 1940... | 3,488,000 | 2,056,000 | 5,544,000 |
| Percent Change. | +9.1 | +174.1 | +40.5 |
| **July:** | | | |
| July, 1939.... | 2,539,000 | 608,000 | 3,147,000 |
| July, 1940.... | 3,981,000 | 2,000,000 | 5,981,000 |
| Percent Change. | +56.8 | +228.9 | +90.0 |
| **1st 7 Months:** | | | |
| 1939..... | 15,860,000 | 4,048,000 | 19,908,000 |
| 1940..... | 21,333,000 | 14,400,000 | 35,733,000 |
| Percent Change. | +34.5 | +255.8 | +79.5 |

U.S. IMPORTS OF CRUDE AND REFINED OILS FOR DOMESTIC USE




Source of Data: Bureau of Mines.

## *Federal Gasoline Tax Up in August; Pipe Line Drops*

Collections from the federal taxes on gasoline and lubricating oils jumped sharply in August as a result of the defense increases of one half cent per gallon which were applied beginning July 1 under the 1940 revenue act, it was reported by the Internal Revenue Bureau.

August collections from the gasoline tax amounted to $33,455,757.75 as compared with $17,595,718.33 in July and $20,163,543.32 in August of last year, while receipts from lubricating oil amounted to $5,072,407.90, compared with $2,272,096.62 in the preceding month and $2,576,281.39 in the same month of 1939, the bureau announced.

Revenue from the tax on pipeline transportation, despite the increase from 4 to 4½ percent, was at a very low level, only $382,573.45 being collected as against $1,690,853.55 in July and $1,022,073.35 in August, 1939.

With the increased revenue from the defense tax, total collections from gasoline for the first eight months of the current year jumped to $158,811,047 as compared with $137,835,536 in the corresponding period in 1939, while the return from lubricating oils reached $22,474,340 as compared with $19,108,098. Despite the low August revenue, collections from transportation totaled $8,041.477 for the eight-month period, against $7,404,014 last year.

# THE CHOICE FOR CONTROLLING SPECIAL GASOLINE TREATMENT

WHEN you put a Bristol's instrument to work for you on important petroleum processing, you will immediately be impressed by Bristol's accuracy, responsiveness, simplicity. These three features are adequately demonstrated here at the Barber Asphalt Corporation, Barber, N. J. as in many other plants which are now served by Bristol's Controllers and Recorders.

Bristol's Automatic Controllers give extremely accurate results. What is more, they stay accurate, regardless of severe operating conditions.

A Bristol's is responsive. Whether the temperature, or pressure, or other quantity changes violently or imperceptibly, quickly or gradually, a Bristol's detects every fluctuation and controls within the prescribed limits.

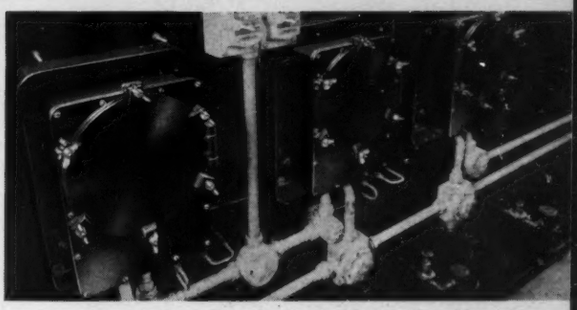
Simple, rugged, *practical,* a Bristol's is just the instrument you need for insuring fine performance.

THE BRISTOL COMPANY, WATERBURY, CONNECTICUT

Branch Offices: New York, Boston, Philadelphia, Pittsburgh, Birmingham, Akron, Detroit, Chicago, St. Louis, Los Angeles, San Francisco, Seattle. Canada: The Bristol Company of Canada, Limited, Toronto, Ontario. England: Bristol's Instrument Company, Limited, London, N.W. 10

## ENGINEERING INSTRUMENT DATA FOR SOLVING YOUR PROCESSING CONTROL PROBLEMS

BRISTOL'S
TRADE MARK REG. U. S. PAT. OFF.
*Control*
FOR PETROLEUM PROCESSING



Rear view of three Bristol's Explosion-Resisting Pyromaster. Pyrometers installed in the gas plant of a major refinery.

### Bristol's Pyromaster Electric Thermometer Air-Operated Controller and Recorder

The Pyromaster Electric Thermometer is a modern development in the field of temperature measurement and automatic control. It operates on the potentiometer principle and has many outstanding features that make it a highly desirable instrument for controlling modern plant processes.

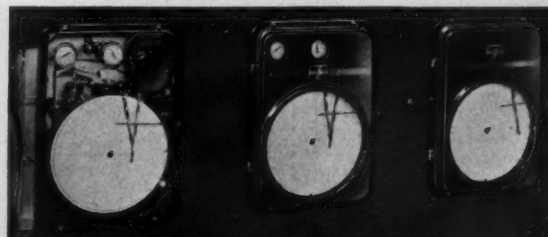
1. The temperature-sensitive element is small, regardless of the length of the connecting leads, and can be inserted at points where only a limited amount of space is available, such as in small pipe lines. The temperature-sensitive element can be easily replaced on the job should it become damaged.

2. The Pyromaster employs electrical conductors between the temperature-sensitive element and the instrument. Long lengths of cable are thus made possible at reasonable cost. This cable can be easily lengthened or shortened on the job, or repaired should it become broken.

3. The Pyromaster lends itself better than any other thermometer to applications where long lengths of cable are required; for example, top tower temperature or for measuring and controlling temperatures in plants where the instruments are centrally located on a panel.

4. An extremely accurate record is made on a 12-inch circular chart, which can be easily filed with other 24-hour records. Full-scale ranges as low as 20°F. are offered.

Another installation of Bristol's on important petroleum processing,—from left to right (*a*) Pyromaster Resistance Thermometer, (*b*) Pyromaster Temperature Recorder Controller, and (*c*) Pyromaster Recording Thermometer.



THE BRISTOL CO., WATERBURY, CONN.

Please mail technical literature on items checked

- ☐ Catalog 4050R Air-Operated "Free-Vane Control For Refinery Processes"
- ☐ Bull. 460R "Coordinated Process Control"
- ☐ Bull. 507R "Pyromaster Potentiometer Pyrometer"
- ☐ Bull. 515, 530, 533R "Metameter For Remote Measurements"
- ☐ Bull. 447, 460, 534R "Process Cycle Control"
- ☐ Catalog 1452R "Wide-Strip Pyrometer"
- ☐ Catalog 1051R "Electric Flow Meter"

*Name*_____

*Address*_____

# Recycle of Stabilizer Bottoms

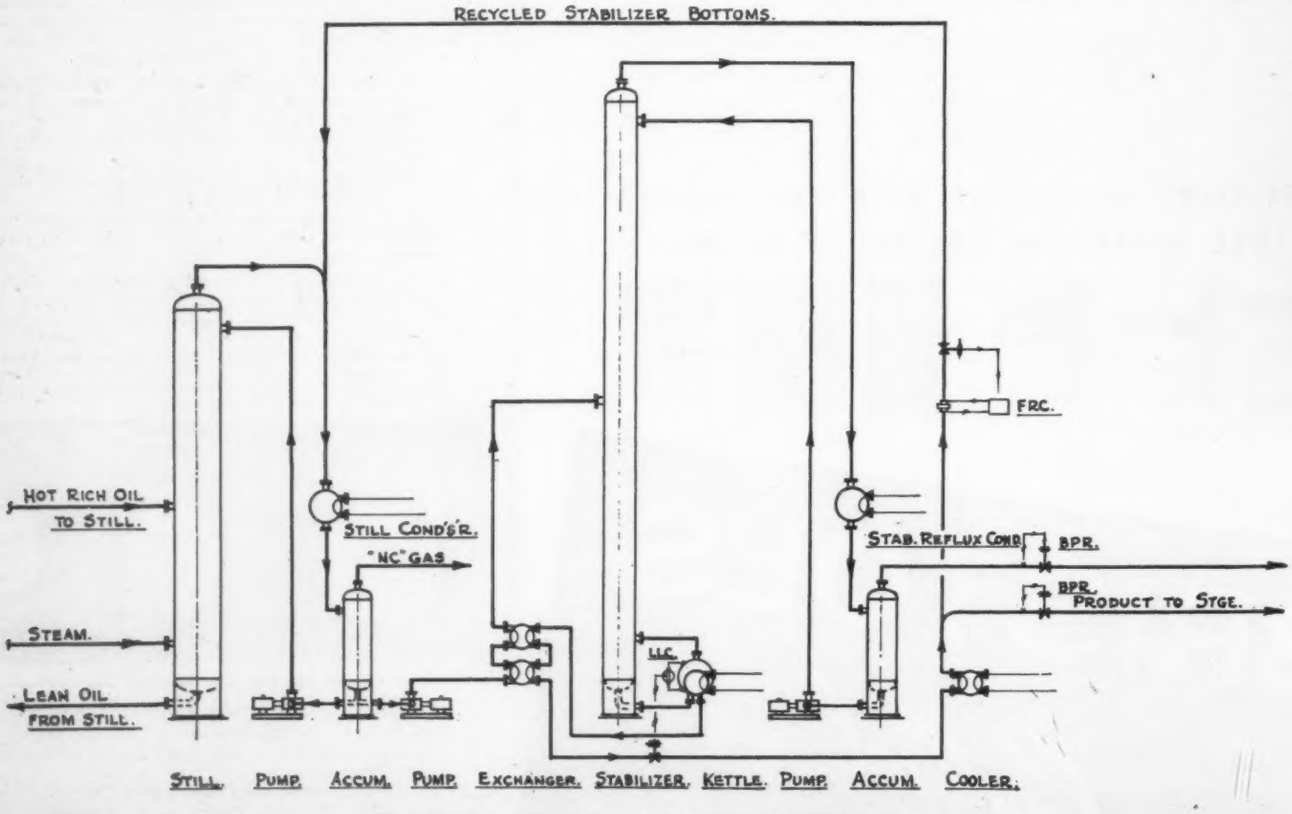
In any process where condensation of vapors takes place, it is sometimes desirable to secure as large a percentage of condensation of vapors as possible. The percentage of condensation of a vapor of given composition depends upon both the temperature and pressure at which equilibrium is established between the condensed fraction and the non-condensed fraction of the initial vapors. In most gasoline plants, the temperature at which condensation takes place is controlled by the temperature of the cooling water available. The pressure is governed by other phases of the process. It is sometimes impossible to vary these two factors sufficiently to obtain the desired results, except by the use of uneconomical compression or refrigeration.

Assuming that the pressure and temperature of the equilibrium conditions cannot be varied economically sufficiently to obtain the desired result, the only other method of securing a greater percentage of condensation is to change the composition of the phase or phases which are in equilibrium. In the case of hydrocarbons, the percentage of condensation is proportional to the ratio of the amount of heavy to light constituents in equilibrium. By introducing a stream of heavy constituents to the zone of condensation, this ratio can be increased and greater condensation will result.

To obtain the desired final product it often is necessary to secure a percentage of condensation which is not possible at the pressure and temperature at which equilibrium is established. As an example, if a process is to give 100 percent butane recovery, no butane should be lost from the still condenser. If any butane is lost from this condenser because of improper condensation, it would have to be recovered elsewhere, which would entail the installation of additional expensive equipment. If a stream of heavier constitutents were introduced into the still condenser in the proper quantity, the desired condensation and therefore the desired composition of the condensed fraction could be obtained.

The source of this heavier material should be as nearly as possible independent of all plant operation conditions or of change in feed materials. The only such source of supply is the finished product from the stabilizer. Regardless of variance in the composition of the stabilizer feed, the final product is controlled to meet sales specifications.

This finished product from the stabilizer or "stabilizer bottoms" may be recycled to the still condenser in sufficient quantity to




**Typical Flow Showing Recycle of Stabilizer Bottoms**

Photo shows the Super-Diamond Pattern of "A. W." Rolled Steel Floor Plate. Provides safe tread from any angle, under any condition.

**For every "floor trouble zone"...** Some floors are habitually damp or greasy. Others quickly become hazardous. "A.W." Rolled Steel Floor Plate eliminates floor trouble zones because it is permanently non-skid. Prevents costly slipping and falling accidents. Reduces maintenance expense. Oil-proof, heat-proof, fire-proof, crack-proof. Easy to clean, quick to drain. Can be cut to any shape and installed almost overnight. Write for folder giving complete engineering data on "A.W." Rolled Steel Floor Plate.

# ALAN WOOD STEEL COMPANY

MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N. C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

# has "what it takes"

**FOR OIL FIELD SERVICE**

**Exceptionally high discharge capacity . . . has a full throat tube seat area, no restriction of the flow. Disc is top-guided.**

**Standard construction is cast steel body with monel trim, but can be furnished with any trim specified. Two-inch size only.**

**MODEL WTN-O**
***Also furnished with exposed spring***

**Lonergan**

# Valves . . .

**GAUGES • SPECIALTIES**

***300 Specialties for Power Plants—Since 1872***

**J. E. LONERGAN COMPANY • 211 Race St., Philadelphia, Pa.**



# *To Improve Cast . . .*

**New Fluorescent Green produces a "Pennsylvania Cast" in lube oils. It is an additive which definitely will improve the salability of your lubricants.**

## *New Fluorescent Green:*

**Solubility . . . . . readily and complete**
**Color . . . . . unchanged by transmitted light**

**STABILITY:**
**light . . . . . fast**
**heat . . . . . stable**
**storage . . . . . stable**

**TESTS:**
**carbon residue . . . . . unchanged**
**fire . . . . . unchanged**
**flash . . . . . unchanged**

**Leading lube refiners in the United States and abroad have used Wilmot & Cassidy products for the past ten years.**
***For samples, prices, and information please write to:***

# Wilmot & Cassidy, Inc.

**108 PROVOST ST. BROOKLYN, NEW YORK**


produce total condensation, or if this is not desired, it may be recycled at a rate which will give any desired percentage of condensation between total condensation and that obtainable if no stabilizer bottoms were recycled. The actual quantity to be recycled depends upon plant design and operating conditions, composition of plant feed and the desired final product.

In nearly all gasoline plants it is desirable to keep the recycled vapor load as low as possible. Any constituents which are desired in the final product and which are not condensed in the still condenser to be recovered must be reabsorbed in a reabsorber or condensed by the use of a recompressor. By the addition of stabilizer bottoms to the still condenser the recycle vapor load from the condenser can be partially or totally eliminated as desired. Then, if a reabsorber or a recompression cycle is necessary to recover desired constituents from vapors which have been vented from other portions of the plant, its efficiency of operation will be greatly increased.

The recycled stabilizer bottoms may be added directly into the still condenser as liquid or may be used as reflux over the still. The effect upon the condensation in the still condenser is exactly the same. From an equilibrium standpoint it makes no difference in the final result whether the recycled stabilizer bottoms enter the condenser as a vapor or as a liquid.

Large quantities of stabilizer bottoms may be recycled to the still condenser with very little effect upon the stabilizer itself. The recycled stock is returned to the stabilizer along with the condensed vapor fraction from the still condenser. As it is desired to recover all of the recycled stabilizer bottoms, this portion of the stabilizer feed is not vaporized in the stabilizer but merely passes through in the liquid state.

The recycling of stabilizer bottoms in no way effects the operation of the main absorbtion unit other than to decrease the quantity of recycled vapors. The recycling of stabilizer bottoms is by far the most economical and efficient method of obtaining the desired recovery of saleable fractions. Recycle of stabilizer bottoms is a new and exclusive process development of The Fluor Corporation Ltd., Los Angeles.

## *Military Theme For NPA Program*

The role of oil in national defense as well as actual war was the theme of the program for the thirty-eighth annual meeting of the National Petroleum Association, Atlantic City, September 18-20. Speakers from army, navy and air force services and men from within the industry gave the two general sessions' views on what the industry will be expected to do in the military program.

In his annual address N. H. Weber dealt with conditions within the industry and in relationships with the government. In regard to the latter he said:

"I am confident that no national emergency will arise which will require the government to assume control either of production or prices in any important industry. During the first world war the oil industry was in a much less favorable position to furnish the petroleum products which were so vitally required by our allies, by our own military forces and by our normal domestic commerce. At that time supplies were limited and we had some gasolineless Sundays. Today, our proven reserves and stocks are at an all-time high. We say to our government and to our regular customers: 'Tell us what you need and we will supply it. Tell us where you want it and we will deliver it there. You will have no complaint to make about our prices.'"

His remarks as to the threat of war were:

"The oil industry is also like all American industry in not wanting war. We are sensible enough to know that war means cruel losses in human lives and wasteful losses of serviceable property. We know that it destroys the culture and the amenities which make life worth living. We also know that it brings an inevitable future day of reckoning, no matter who wins. We have had too much fostering of class hatreds in peace. We don't want to add to them the race hatreds of war. We cannot believe that any emergency justifies dictatorships. We still think of our government as an institution to serve us, not to manage our lives. We still want the greatest measure of freedom that is consistent with freedom to others."

In his paper, "Pennsylvania Oils for National Defense," Cary R. Wagner, chief chemist of The Pure Oil Company, Chicago, traced the history of both products and markets of oils for the area and pointed out that the airplane motor, like the automobile motor, is by mechanical improvements using less lubricating oil per mile of travel. He said that under normal development of the airplane it could not be expected to absorb the excessive bright stocks of Pennsylvania oils, and added:

"However, we are today witnessing an accelerated production and development schedule unprecedented in history. Purchases of planes of every kind and description herald a new era for aviation and hold promise of vastly expanded markets for Pennsylvania lubricants. Since Pennsylvania oils already supply the large majority of commercial air-line lubrication needs, it is a reasonable assumption that they will enjoy proportionately the increased business which an enlarging commercial flying service will make possible. Furthermore, there is projected a great increase in mechanized equipment for ground military forces such as tanks, transport trucks and mobile artillery units which will require lubricants capable of unfailing performance under exacting conditions. All this is definitely in the future, to be sure, but commencing in 1941 will rapidly approach reality."

His warning to the industry was that it should not depend on emergencies to create its markets. He recommended a research program in behalf of lubricants from Pennsylvania oils and pointed out that the expense of the program may well be less than the cost of not finding markets.

An analysis of foreign trade, especially as it applies to the oil industry, was given by Eugene P. Thomas, president, National Foreign Trade Council. A discussion of current topics in Washington was given by Ray Tucker, newspaper columnist of Washington to complete the program of September 18.

The general program for the second day began with the paper, "Integration, the Key to Efficiency in the Petroleum Industry," by Joseph E. Pogue, vice president of Chase National Bank, New York. He classed integration as a normal development in an industry which is being charged with using integration to stifle non-integrated concerns and recommended some changes in methods of operation as a way to meet these charges. Of integration he said:

"The integrated pattern was the simple economic motive for finding means to reduce the hazards in a speculative enterprise by equalizing the risks inherent in the separate departments of the business, after the analogy of crop diversification in agriculture. The trend toward integration was enhanced by certain technological features of the industry, such as the liquidity and inflammability of the materials which practically necessitated special forms of transportation; the volume of commodities involved which induced the application of mass production principles; the joint-product nature of the processed output which required the development of new markets for the unwanted fractions, and the need for reaching the consumer at manifold points of utilization with small deliveries, which promoted specialized marketing facilities. In fine, integration is the resultant of the impact of a wide range of factors, economic, financial and physical, which have made inevitable the development of this convenient operating pattern for utilizing the petroleum resource."

Because of complaints against integration, he offered this recommendation:

"So great, however, is the pressure for quick action, which could only result in disruptive consequences, that it might be desirable to speed up the processes of orderly change by giving more concerted attention to the points at issue. Thus, the focal points of irritation could be eradicated by encouraging more frequent and smaller changes in crude oil prices, in closer harmony with costs and realizations; prompt adjustments in pipe-line tariffs in all cases where previous alterations have not brought postings into reasonable conformity with costs, considering risks; and the introduction of a system of quantity discounts to jobbers and dealers based upon real differences in costs, so as to obviate any hint of preferential treatment to any class of outlets."

Robert H. Hinkley, assistant secretary of the Department of Commerce, "Relation of Civil Areonautics to National Defense," and W. Averell Harriman, National Defense Advisory Commission, "Progress in Preparedness," completed the final general session.

For the morning of the second day, Colonel R. N. Atwell, United States Army, quartermaster corps, Colonel Raymond Marsh, ordinance department, and Commander W. C. Latrobe, United States Navy, gave details of what the military services will need in national defense. All pointed out that the adoption of standards, which would involve fewer fuels and lubricants, would be an advantage to the military units.

All officials of the association were reelected: N. H. Weber, The Pure Oil Company, president; C. L. Suhr, Pennzoil Company, executive vice president; H. A. Logan, United Refining Company, and Otto Koch, Kendall Refining Company, vice presidents; Herbert G. Eaton, Superior Oil Works, recording secretary, and G. B. Hunter, Quaker State Oil Refining Company, treasurer.

# The Look Box

### Conventions

| | |
|---|---|
| Oct. 17–18 | American Institute of Mining and Metallurgical Engineers, Petroleum Division, Los Angeles. |
| 25 | Western Petroleum Refiners Association, Ark-La-Tex Division, Regional Meeting, Washington-Youree Hotel, Shreveport. |
| NOV. 1 | California Natural Gasoline Association, Ambassador Hotel, Los Angeles. |
| 5– 6 | American Recycling Association, Annual Recycling Short Course, Texas College of Arts and Industries, Kingsville, Texas. |
| 11–15 | American Petroleum Institute, Stevens Hotel, Chicago. |
| DEC. 2– 6 | American Institute of Chemical Engineers, New Orleans. |
| 9–14 | National Asphalt Conference, Dallas. |
| 11–15 | National Chemical Exposition, Stevens Hotel, Chicago. |

## *C. N. G. A. Program November 1*

A technical program and a banquet in the evening will make up the program of the fifteenth fall meeting of the California Natural Gasoline Association, Ambassador Hotel, Los Angeles, November 1.

Accomplishments of the association will be outlined by L. V. Cassady, president, whose subject is, "C. N. G. A. and Its Accomplishments During Its First Fifteen Years." The report of the technical committee will be heard at this session with M. W. Kirbe, General Petroleum Corporation, chairman. Reports of three subcommittees will be on this part of the program, when three new bulletins will be presented. These

reports will be by D. A. Smith, Tide Water Associated Oil Company, on the new bulletin "Physical Constants of the Components of Natural Gas and Gasoline"; Francis Laird, The Texas Company, on the new bulletin, "Low Temperature Fractional Analysis of Natural Gas and Gasoline," and C. B. Heartwell, Standard Oil Company of California, on the bulletin, "The Chartman's Manual."

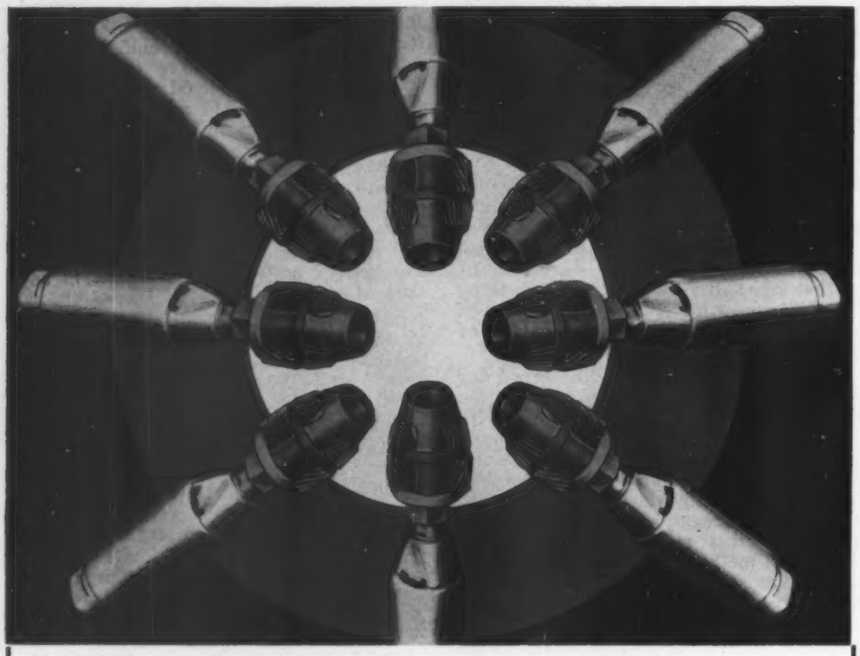
A feature of the morning session will be a paper by the research department, United Geophysical Company, titled "Application of Mass Spectrometry to Analyses of Hydrocarbon Gas Mixtures." This paper records the progress made in the application of mass spectrometry to gas analyses.

The afternoon session will start with Henry N. Wade, Parkhill-Wade, whose paper, "Distillate Recovery Systems," will give data on high-pressure absorption. He will comment on the various types of distillate plants giving a comparison of costs, advantages and disadvantages.

The second paper of the afternoon session will be "Processes for the Conversion of Light Hydrocarbons to High Anti-Knock Aviation Fuels," by S. H. McAllister, Shell Development Company. McAllister will review the present commercial methods for the production of high-octane fuels including various polymerization processes and alkylation, both thermal and with sulphuric acid, as well as the latest processes such as hydrogenation and dehydrogenation.

Closing the afternoon meeting, C. E. McCartney, Petrolane, Ltd., will present "Commercial Butane, a Waste Material, Becomes a Valuable Product." He will present a brief history of the expansion of the liquefied petroleum gas industry over the last 15 years, pointing out that commercial butane has a much greater economic value that the present market indicates and that it should be considered a product and not a waste material and, as such, it should carry its proportional share of plant overhead and plant operation. This paper will also deal with the use of commercial butanes for alkylation and chemical processes, the existing market for the product and the fact that it is a premium fuel in many types of equipment and operations.

The association's annual banquet will be held in the Ambassador Hotel Fiesta Room at 7 o'clock.

**CUT TUBE CLEANING COSTS**

**For faster, better and more economical tube cleaning, use Wilson E P (Extra Power) Series Heavy Duty Air Motors—especially designed for removing very hard or heavy coke or scale from refinery tubes.**

**The Wilson E P (Extra Power) Series cleaners, illustrated above, use from 25% to 40% *less air* but develop from 30% to 75% *more power* and clean tubes *cleaner* and at less cost than ordinary tube cleaners of the same size.**

**There is a Wilson Tube Cleaner, Cutter Head or other accessory especially suitable for cleaning any refinery tube or pipe that can be cleaned mechanically.**

**Let us help you solve your tube cleaning problems. Write for the name of our representative nearest to you or send for a copy of our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.**

**THOMAS C. WILSON, Inc.**
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.


## *A.G.A. Elects Officials*

Officials of the American Gas Association, elected at the annual meeting in Atlantic City, October 8, are:

President, T. J. Strickler, Kansas City Gas Company, Kansas City, Missouri;

First vice president, George F. Mitchell, Peoples Gas Light and Coke Company, Chicago;

Second vice president, George S. Hawley, Bridgeport Gas Light Company, Bridgeport, Connecticut;

Treasurer, Ernest R. Acker, Central Hudson Gas & Electric Corporation, Poughkeepsie, New York.

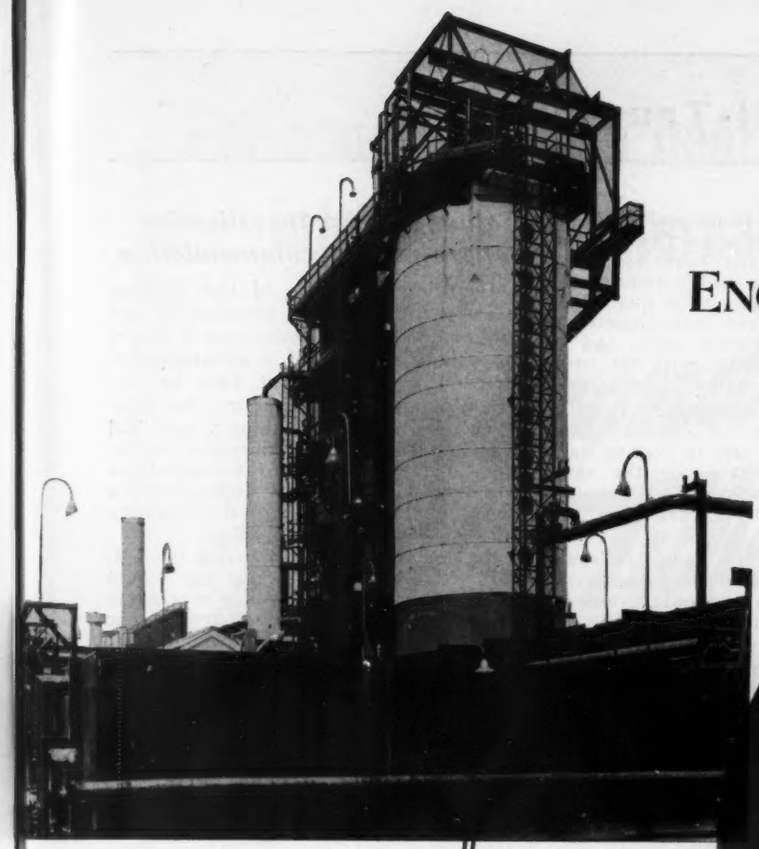
Directors chosen for two-year terms are: John W. Batten, Michigan Consolidated Gas Company, Detroit; A. F. Bridge, Southern Counties Gas Company, Los Angeles; James A. Brown, Commonwealth & Southern Corporation, New York; D. W. Harris, Arkansas Natural Gas Corporation, Shreveport; Conrad N. Lauer, Philadelphia Gas Works, Philadelphia; H. N. Mallon, Dresser Manufacturing Company, Bradford; F. H. Payne, American Meter Company, Erie; Herman Russell, Rochester Gas & Electric Corporation, Rochester; N. Y. Sellman, Consolidated Edison Company, New York and Marcy L. Sperry, Washington Gas Light Company, Washington.

## *Roberts Heads Petroleum Division*

J. K. Roberts, director of research for Standard Oil Company (Indiana), was elected chairman of the petroleum division of the American Chemical Society at the annual meeting in Detroit, September 10-11. The technical program of the division was confined to two days of the week required for the annual meeting of the society.

M. R. Fenske, Pennsylvania State College, was chosen vice chairman, and C. R. Wagner, chief chemist, The Pure Oil Company, Chicago, was re-elected secretary. Except for one year as chairman, Wagner has been secretary of the division for 11 years.

Per K. Frolich, Standard Oil Development Company, retiring chairman, was elected to the board of directors. E. C. Williams, Shell Development Company, also was elected to the board.



# ENGINEERS AND CONSTRUCTORS *for the* PETROLEUM INDUSTRY

Specialties — Houdry Catalytic Process
Edeleanu Process

General — Crude Distillation Units
Vacuum Units
Cracked Distillate Rerun Units
Pressed Distillate Rerun Units
Solution Rerun Units
Thermal Cracking Units
Viscosity Breakers
Solvent Extracting and Dewaxing Units
Asphalt Units

***In*** **addition to our extensive work in connection with licensing and building Houdry Catalytic Cracking and Treating Units during the past year or two, we have been active in general refinery engineering and construction. Atmospheric and vacuum distillation units and dewaxing plants stand out prominently in this phase of our work. Sizes of units designed and constructed range from 500 to 90,000 barrels daily capacity.**

**Badger offers a complete service staffed to handle projects anywhere.**

**Licensing Agents for the Houdry Catalytic Cracking Process**

## E. B. BADGER & SONS CO.

**Boston, Mass.**

**New York • Philadelphia • San Francisco • London • Paris**

*Engineers and Contractors*
*for Petroleum Distillation and Refinery Equipment*

# Federal Anti-Trust Suit

## *Government's Action Drops Plea for Disintegration*

The Department of Justice has launched its long-expected suit against the oil industry, but devoid of the demand for disintegration which last month aroused the vigorous opposition of the National Defense Advisory Commission.

The department, on September 30, filed its complaint in the Federal Court for the District of Columbia, attacking the buying and marketing practices of 22 major oil companies and their subsidiaries and affiliates and naming the American Petroleum Institute as a party to the proceedings.

At the same time, Attorney General Robert H. Jackson announced that suits would be filed against three pipe line companies under the Elkins Act and, in a letter to Senator Guy M. Gillette of Iowa, urged that Congress enact such divorce or other legislation as may be necessary to protect the Nation's oil reserves.

While the disintegration issue is not now to be pressed, the department emphasized that it had not been abandoned, but may be revived at a more opportune time or even in the trial of the suit just filed if it appears "that the abuses in the oil industry can be corrected in no other way."

The 22 companies named in the suit are The Atlantic Refining Company, Barnsdall Oil Company, Cities Service Company, Consolidated Oil Corporation, Continental Oil Company, Gulf Oil Corporation, Mid-Continent Petroleum Corporation, The Ohio Oil Company, Phillips Petroleum Company, The Pure Oil Company, Shell Union Oil Company, Skelly Oil Company, Socony-Vacuum Oil Company, Standard Oil Company of California, Standard Oil Company (Indiana), Standard Oil Company of Kentucky, Standard Oil Company of New Jersey, Standard Oil Company of Ohio, Sun Oil Company, The Texas Corporation, Tide Water Associated Oil Company, Union Oil Company, and approximately 330 subsidiaries.

### Against Producers

For the first time in its current trust-busting campaign, the government went into the production phases of the industry, charging, among other things, that the defendants:

Have conspired to fix and maintain, uniform, noncompetitive prices to be paid by them for crude purchased from independent producers and to be charged by them for crude sold to independent refiners;

Have conspired to restrict the production of crude oil and the manufacture of petroleum products;

Defendants who control gathering systems have conspired to compel independent producers who have no other practical means of transporation to competitive markets, to sell crude to the defendants at the well rather than permitting the independents to use such pipe lines on a common-carrier basis;

Have agreed to adopt and file with the Interstate Commerce Commission rules and regulations covering interstate transportation which require the tender of unreasonably large quantities; to maintain uniform noncompetitive, onerous and oppressive rates, and to fail to provide shippers with the ordinary common-carrier terminal facilities;

Have conspired to charge excessive rates for the use of crude-oil and gasoline pipe lines and to receive back as refunds and rebates on the rates charged to themselves a substantial part of the revenue from pipe line operations;

Have conspired to cause railroads to establish and maintain rates favorable to themselves and unfavorable to independent refiners;

Have acquired a dominant control over tankers, barges, tank cars and other transportation facilities, and have conspired to maintain excessive rates for their use;

Have conspired to distribute their products only through facilities operated by persons or companies whose buying, selling and operating policies can be controlled, thus obtaining control over practically all bulk plants through which petroleum products pass from refineries to service stations.

In addition, the complaint charged that the companies have conspired to control retail marketing by controlling filling stations, granting differentials to exclusive dealers, forcing full-line selling, fixing prices and marketing and price policies and enforcing exorbitant price differentials between various grades of gasoline.

### Dissolve Institute

With respect to the American Petroleum Institute, the government charges the defendants unlawfully combined to create and utilize the association and its various committees as an instrumentality for promoting, supervising and enforcing the various illegal policies and practices set forth in the complaint.

The petition seeks an injunction against the continuance of these and other practices and dissolution of the Institute.

The decision of the department to confine the suit to these issues, rather than to force the disintegration demand at this time, was disclosed in a letter from the Attorney General to Senator Gillette, who had led a Congressional group in a demand that the government proceed immediately with the case.

Because of the problem of national defense, Jackson wrote, the department had adopted the recommendations of the National Defense Advisory Commission.

"The Defense Commission advised me that it would wholeheartedly approve 'any appropriate legal action brought to eliminate such restraints on competition where they are proven to exist,'" he said. "In accordance therewith I have authorized the Anti-trust Division to commence the proposed

[*Continued on page 104*]

## *Solons Call for Investigation Of Defense Recommendation*

Charging that nine of the 11 men who participated in formulating the National Defense Commission's report opposing inclusion of a disintegration demand in the oil suit filed by the Department of Justice in the District of Columbia Federal Court had a personal interest in the matter, members of both houses of Congress on October 4 joined in a demand for a thorough investigation of the handling of the case.

In the upper house, Senator Guy M. Gillette served notice that he would reintroduce his bills for divorcement of pipe lines and marketing from other branches of the industry and press for action on the legislation next session, and in the House of Representatives, Congressman John M. Coffee urged adoption of his resolution for investigation of the enforcement of the anti-trust laws.

Reviewing the history of the suit filed September 30, Gillette expressed gratification over the action and told the Senate that "for a long time, there were many of us who felt that the large, integrated oil companies were taking advantage of a situation which ought to be corrected."

The senator put into the record letters which indicated that on August 14 he wrote Assistant Attorney General Thurman Arnold that unless good reasons could be given for the delay in bringing suit he would reopen hearings on his bills, which had been suspended at the department's suggestion, and was informed by Arnold that the matter had been referred to the National Defense Commission.

A month later, he wrote to the attorney general and after 10 days received a reply that the commission had made a report and the case was about to be filed.

### "Standard and Shell"

"Without making any insidious or unfair attack," he said, "I should like to refer to the fact that of the eleven members of the advisory commission to the Council of National Defense who had this matter under consideration, nine were connected with the Standard Oil Company or with the Shell Oil Company and had a personal interest in the subject matter.

"I do not mean to suggest that it is improper to have on the Council of National Defense men conversant with the oil industry. It was highly proper. It was very essential to have on the commission men with some knowledge of the industry; but I want the fact to appear that of the eleven men who were considering the effect of these suits, nine were actual potential defendants if the suits were filed."

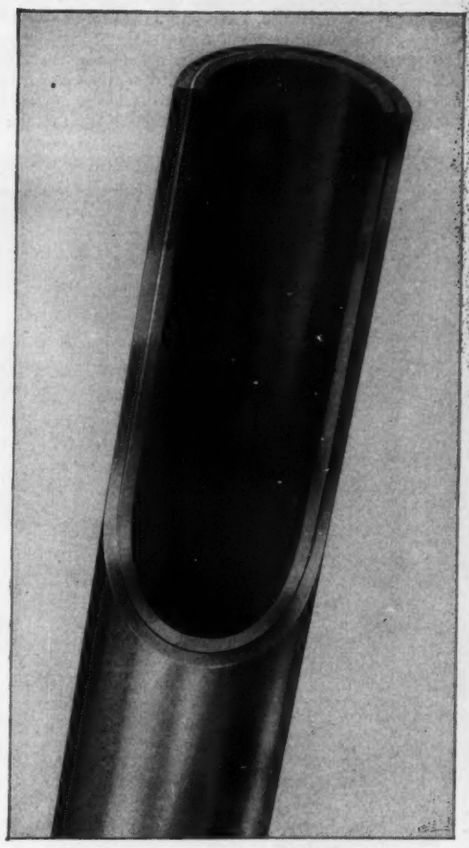
Because of these delays, Gillette pointed out, it will be impossible to get action on his bills this session, "but it is my intention in January, when the next Congress assembles, to reintro-

# For condenser and heat exchanger tubes where internal and external conditions differ...

# Anaconda Duplex Tubes

In oil refineries, it is common to find corrosive conditions on the inside of condenser and heat exchanger tubes differing entirely from those encountered on the outside. Since there is no *one* tube alloy best suited to meet *all* operating conditions there is a definite need for tubes whose inside and outside surfaces possess altogether different characteristics.

The American Brass Company is prepared to fill that need with Anaconda Duplex Tubes. They are composite tubes made by tightly telescoping two seamless tubes of different metals.



Cutaway section of Anaconda Duplex Condenser Tube.

### Wide range of sizes and alloy combinations available

Anaconda Duplex Tubes are available in sizes ranging from ½″ O. D. x .025″ gauge to 5″ O. D. x .250″ gauge. Maximum lengths are from 18 to 20 feet, depending upon diameter and gauge.

Anaconda Duplex Tubes can be obtained in various combinations of Anaconda Copper Alloys or any of these Anaconda Copper Alloys with iron, steel or other metal. Our engineers will gladly assist you in determining the most suitable combination of metals to meet specific conditions. 40112

### IN ADDITION—

The American Brass Company produces a complete line of copper and copper alloy condenser and heat exchanger tubes and tube sheets.

Your written request will bring immediate information on Anaconda Duplex Tubes—and will also assure your early receipt of our new, comprehensive booklet on Anaconda Condenser Tubes which will be off the press very soon.

ANACONDA

## Anaconda Copper & Brass

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

*In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company*

duce these measures substantially as they are at this time.

"I wish to give notice that as soon as they are introduced I shall have them referred, if possible, to the same subcommittee to resume the hearings where they were left off," he said.

### Won't Tolerate Supervisory Board

At the same time, the senator struck out against proposals for setting up a supervisory body over the industry as suggested in reports of conferences between Secretary of the Interior Harold L. Ickes and industry representatives.

"I do not know whether or not that report is true," he declared. "The only authority I have for it is a number of excerpts and clippings which were sent to me reciting that such is the plan. But I wish to give notice now that no supervisory body composed of the secretary of the interior, or any other official, and Mr. Teagle or anyone else representing the oil companies, shall supersede the legislative rights of the American Congress to go into this whole field. When this proposed legislation is reintroduced, if such a body is contemplated or appointed, it will not deter or delay, so far as I am able to secure action, proper action, by the Senate of the United States."

Reciting the names and connections of oil men connected with the defense commission, Coffee told the House that, "until otherwise shown, every one of these gentlemen is under a cloud of having had something to do with the preparation or contents of the report of the Council of National Defense on the oil anti-trust suit.

"These men are practically all connected with companies which would be affected by the proposed anti-trust suit to bring about pipe-line divorcement and marketing divorcement in the oil industry," he said. "They are real parties at interest; and if they had any part in the decision of the Council of National Defense, their activity may be only the prelude to the defeat of our democratic form of government. It is not a democratic process to permit the employes of the accused to serve on a jury, nor should they be permitted to pass judgment on a case before it is submitted to the courts for vindication."

Coffee said then he had been "reliably informed" that serving on the commission are Dr. Robert E. Wilson, principal oil adviser, president of Pan American Petroleum & Transport Company; C. C. Monrad, technical assistant, formerly employed by Standard Oil Company of Indiana; Fayette B. Dow, pipe-line transportation adviser, Washington attorney for the American Petroleum Institute and Washington counsel for many pipe line companies; S. D. Heron, aviation gasoline expert, connected with Ethyl Gasoline Corporation; T. A. Boyd, oil adviser, General Motors Corporation; Walter G. Whitman, chairman of aviation fuels committee, former research expert for Standard Oil Company of Indiana; Dr. D. P. Barnard, oil adviser, associate director of research for Standard Oil Company of Indiana; Gerald H. B. Davis, oil adviser, director of research laboratories of Standard Oil Development Company; Major James H. Doolittle, oil adviser, head of the aviation department of Shell Oil Company; J. Bennett Hill, oil adviser, manager of the development division of Sun Oil Company, and C. R. Dooley, adviser to the labor division, industrial relations manager of Socony-Vacuum Oil Company.

In addition, Coffee referred to the special committee of oil company engineers appointed by Dr. Wilson to advise the Army and Navy on storage systems.

## *Risk Joins Ethyl Staff*

Thomas H. Risk, for the past five years with The Pure Oil Company, has joined Ethyl Gasoline Corporation in the refinery technology division. Risk will extend the technical service offered to refinery licensees through contact with refiners, and will assist in coordinating automotive research activities at the Detroit and San Bernardino engineering laboratories with trends in refinery procedures.

Prior to joining The Pure Oil Company as automotive engineer in 1935, Risk was with Socony-Vacuum Oil Company in the Paulsboro laboratories.

---

Frederick R. Speed, Chesapeake City, Maryland, has been named automotive engineer for the Pennsylvania Grade Crude Oil Association. He succeeds Harry M. Rogg, who died following an automobile accident in July. Speed has had experience in both the automobile and oil industries.

Gasolines that atomize in a flash . . . that burn cleanly . . . that produce smooth, full power for hills, for highways . . . that send planes zooming like comets through the skies!

Contributing to striking recent improvements in gasolines is the cooperation of related industries and processes. In this development of superior gasolines for driving fast-firing, modern engines, SOLVAY has played a three-fold role:

*First*—SOLVAY Technical Service has demonstrated a notably competent character in helping the oil industry to solve many problems arising out of the new petroleum technology.

*Second*—Instead of being limited to a few grades of Caustic Soda to meet their processing needs, individual refiners find that SOLVAY puts at their disposal a wide variety of special grades of this essential refining product.

*Third*—High standards of quality control maintained in the production of *all* SOLVAY products are a governing factor in insuring the uniformity so necessary to modern-day refining operations.

These are among the important factors considered by refiners in filling their Caustic Soda and other alkali requirements at SOLVAY. They know that SOLVAY is unusually well equipped to serve the forward-looking petroleum industry in many helpful ways. Your inquiries in regard to products or processing problems are cordially invited.

*Send for Information on these Solvay Quality Products*

Caustic Soda
Soda Ash
Calcium Chloride
Chlorine
Causticized Ash
Modified Sodas
Para-dichlorobenzene
Potassium Carbonate
Caustic Potash
Ammonium Bicarbonate
Ammonium Chloride
Salt
Sodium Nitrite

**SOLVAY SALES CORPORATION**

*Alkalies and Chemical Products Manufactured by The Solvay Process Company*

**40 RECTOR STREET NEW YORK, N. Y.**

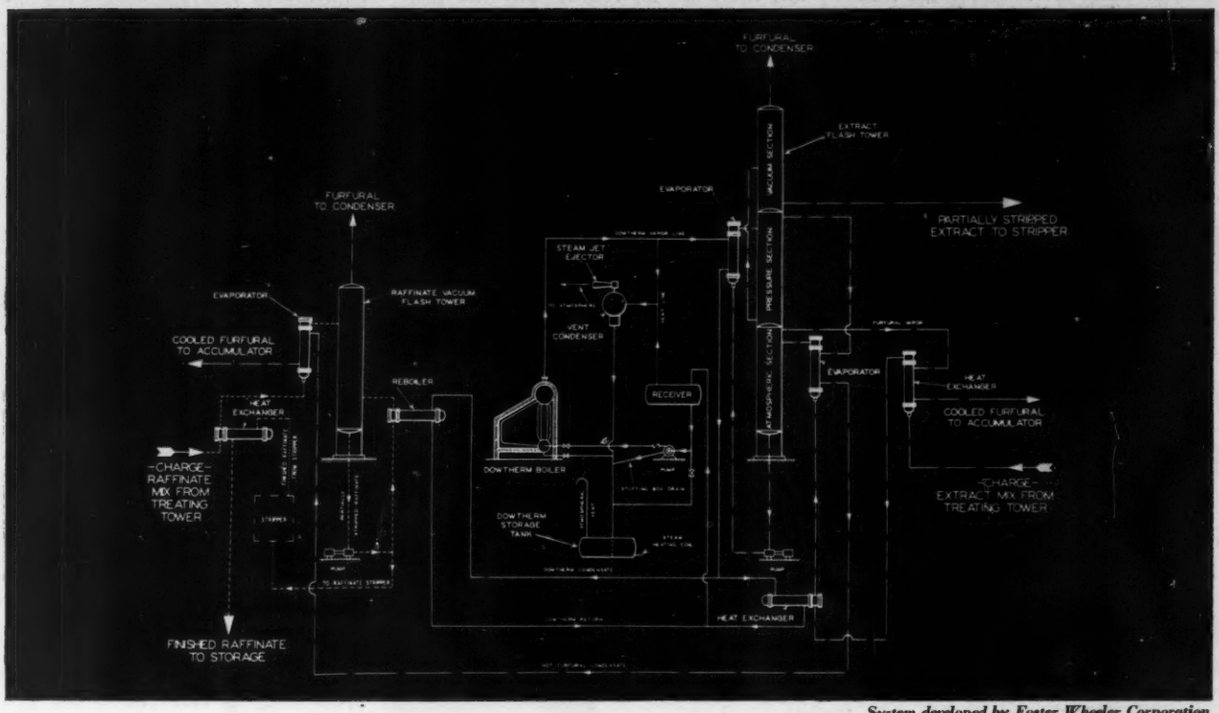
BRANCH SALES OFFICES:

Boston Chicago Cleveland New Orleans Philadelphia St. Louis
Charlotte Cincinnati Detroit New York Pittsburgh Syracuse

*Plants Located At:* Syracuse, N. Y. • Detroit, Mich. • Baton Rouge, La. • Hopewell, Va.

# SOLVENT REFINING WITH DOWTHERM

## THE HIGH TEMPERATURE, LOW PRESSURE, HEAT TRANSFER MEDIUM




*System developed by Foster Wheeler Corporation*

EFFECTIVE protection against local overheating, simplified operation and most accurate regulation of heat application, are attained through the use of high-temperature, low-pressure Dowtherm* vapor as an indirect heating medium in refinery processes.

Precise control is especially desirable in solvent refining processes such as furfural, phenol, and chlorex refining where solvents are recovered at high temperatures—frequently up to 600° F. and above the economic range of steam heating. The flow diagram above shows a furfural solvent process in which Dowtherm vapor and liquid are used in the heating steps involved in solvent recovery. The evaporator for vaporizing the furfural from the extract mixture is heated with Dowtherm vapor and the hot Dowtherm condensate from this evaporator is used to supply heat to other heaters. Part of this condensate serves as the source of heat for a reboiler in which the last traces of furfural are stripped from the finished raffinate. The balance of the Dowtherm condensate flows through another heat exchanger and preheats the extract mixture passing from the furfural treating tower to the evaporator mentioned above.

This use of Dowtherm provides remarkable ease of control in meeting widely fluctuating flow rates in the various stages of the process and prevents concentrated heating with resultant degradation and coking. The fundamental principle of a condensing vapor, that maintains the same temperature throughout the heating surfaces, is the basis of Dowtherm systems. Ordinarily condensate returns to the vapor generator by gravity but in cases of systems operating several heaters from a single vapor generator, centrifugal return pumps are often used.

Dowtherm boils at 500° F. under atmospheric pressure, and at 725° F. at 110 lb. per sq. in. Therefore 150 lb. pressure construction is adequate for high temperature processing with Dowtherm.

TRADE DOW MARK

*Trade Mark Reg. U. S. Pat. Off.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

*Branch Sales Offices:* New York City, St. Louis, Chicago, San Francisco, Los Angeles, Seattle

[*Continued from page 100*]

civil action so far as it seeks to prevent existing abuses in the oil industry, including price-fixing, discriminations, and all practices which tend to restrain or prejudice the independents in the industry or to jeopardize the interests of consumers.

"The Defense Commission indicated that a court decree of divestiture at this time would create a number of serious problems for the national defense. Accordingly, this action does not seek at this time to compel the oil companies to get rid of their pipe lines, barges, or other facilities for the transportation and distribution of petroleum. I believe there might be serious consequences from a disruption of these facilities at a time when we have no capital presently willing, so far as I am able to ascertain, to acquire and operate these facilities by themselves.

"The National Defense Commission, however, referring to the divestiture phase of the case, says 'the commission does not suggest that the proposed suit should be abandoned.' It is not being abandoned, and no action is being taken inconsistent with divestiture proceedings, either in a later action or by amendment of proceedings in the existing suit if, at the time of trial it shall appear that the abuses in the oil industry can be corrected in no other way."

At the same time, he told the Senator, there is "no reason why the pendency of this action in any form should interfere with or delay legislative consideration of the problems of the oil industry," pointing out that many years may elapse before a final decision is reached and that court decrees are in the main "negative affairs forbidding certain acts, combinations and contracts" but not necessarily leading to constructive steps in industry.

"The statement most significant to me in the report of the Defense Commission has been almost wholly overlooked in the discussion of these cases," he continued. "It states 'though by simple arithmetic it would appear that the country's reserves are good for more than ten years under emergency conditions, declining production and higher prices for petroleum will arrive long before exhaustion of reserves unless the discovery rate is maintained and production is effected with a minimum of waste.' The very fact that in considering national defense we begin to calculate the life of our oil reserves in such small figures is an ominous sign for national defense and for our economic life.

"In advocating revision of the anti-trust laws over three years ago to make them effective and clear, I repeatedly said that in my opinion the doctrine of compulsory competition embodied in the anti-trust laws is unwisely applied to oil production where the principle of conservation of an exhaustible and irreplaceable national resource should replace the principle of competitive exploitation. The companies seem to recognize this for they have tried to limit depletion by devices of their own, but without representation of the public interest or the consumer welfare, or that of smaller producers. Private conservation plans which restrain or discriminate against independents and disregard consumer interests violate the anti-trust laws, but they should not be replaced by a headlong race to exhaust petroleum supplies, but rather by a conservation plan which will be in the public interest.

"Only Congress can protect the future economic life of this country by protecting oil reserves in the ground. It has made several efforts to do so, some of which have failed. I believe more comprehensive plans could be devised now which would be successful. Litigation by itself will never completely accomplish the wise utilization of this great asset by this generation or its conservation for the future."

### Three Pipe-Line Suits

The three pipe-line suits which are to be brought will be filed in the Delaware District Court against Phillips Petroleum Company and Phillips Pipe Line Company, in the same court against Great Lakes Pipe Line Company, and in the Northern District of Indiana Court against the Standard Oil Company (Indiana).

"These three suits," the department explained, "were selected as representative proceedings to clarify the law with respect to all cases where pipe lines are owned by the major oil companies. They charge the major oil companies involved with taking rebates from common-carrier pipe lines on the oil which the majors ship. The method by which these rebates are alleged to be taken is as follows: The major oil companies own the capital stock of the pipe line companies, pay the published tariff rates and receive refunds from such rates under the guise of dividends on


# NEED BURNERS?

***(Gas, Oil, or Combination)***

**The John Zink Burner Line is Complete**

**32 different types**

***Designed and Built for Engineers by Engineers***

**There is a John Zink Burner for every purpose:**

POWER
CRACKING
HEATING
DRILLING

JOHN ZINK BURNERS

**JOHN ZINK COMPANY**

Burners • Floor Furnaces • Unit Heaters

TULSA, OKLA. NEW YORK CITY

# 4 Weeks Service

## FROM ORDER TO INSTALLATION on all

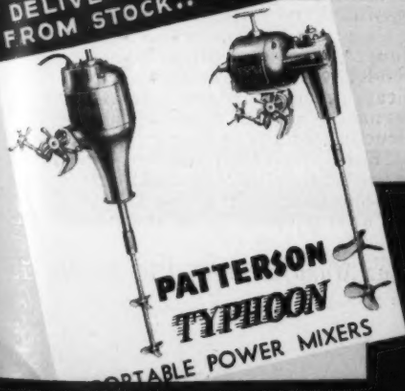
# PATTERSON

## TYPE-M-40 UNIPOWER AGITATORS

SERVICE IN TUNE
TH THE TIMES . . .
standardized production of
M-40 UNIPOWERS benefits
y enabling quick service when
eed it most. As you plan for
production, count on the
wer for performance and on
rson for dependable, quick
ries . . . always!

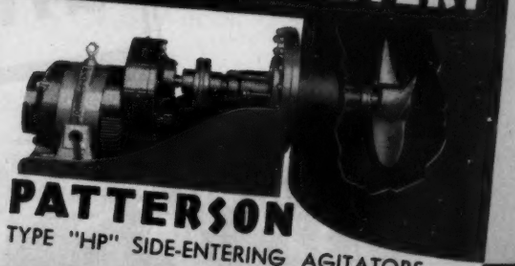
COMPLETE WITH STANDARD TYPE STIRRERS FOR LIQUID MIXING—Check these Type M-40 UNIPOWER features: heavy duty performance — high service factor—tapered roller bearings—built-in oil dam—no leakage around packing—force feed lubrication—built-in guide and thrust bearing in base — immediate repair service!

IMMEDIATE DELIVERY FROM STOCK..



PATTERSON TYPHOON
ORTABLE POWER MIXERS

3 WEEKS DELIVERY



PATTERSON
TYPE "HP" SIDE-ENTERING AGITATORS

THE PATTERSON FOUNDRY & MACHINE CO.
EAST LIVERPOOL, OHIO, U. S. A.

Richard L. Cameron

the stock. During the year, 1939, the net earnings of Phillips Pipe Line Company amounted to 49 percent of transportation revenues; the Great Lakes Pipe Line Company 49.5 percent; and Stanolind Pipe Line Company 36 percent. These earnings were paid back in the form of dividends to the major oil companies which ship the oil, thus giving the major oil company shippers a tremendous advantage over their independent competitors.

"This the Department of Justice contends is an illegal rebate under the Elkins Act."

### Price Fixing

In a lengthy analytical statement of the allegations in the complaint filed in the District of Columbia Court, the department explained that the conspiracy alleged in the fixing of crude prices is carried out by the posting of prices by one of the defendants, which are followed by the others.

"In fields where independent refiners compete with the defendants in the purchase of crude oil, higher prices are fixed, thus putting the independent refiners at a competitive disadvantage and driving them from the market," it was charged. "Through their activities, defendants control practically all of the supply of crude oil available for refining; hence, independent refiners, most of whom do not have independent sources of crude oil, are compelled to purchase all or a large part of their requirements from the defendants at prices fixed by agreement, thereby placing independent refiners at a substantial price disadvantage."

The restrictions on crude production and the manufacture of oil products, it was explained, are alleged to have been "accomplished in part through a system of reports made to the American Petroleum Institute covering the amounts of locations of all stocks of petroleum products owned or held by each of the defendants. From these reports the Institute is able to make suggestions as to the amounts of petroleum products which should be manufactured and maintained in storage. These amounts are less than the amounts which would normally be produced and manufactured. It is alleged that the Institute's suggestions are adopted by the defendants, thereby accomplishing the restrictions. It is charged that the defendants have agreed to receive in their crude-oil-gathering lines from independent producers who are dependent upon such lines for transportation, less crude oil than the amounts which such independents would normally produce, thereby reducing the amount of crude oil produced by the independent producers."

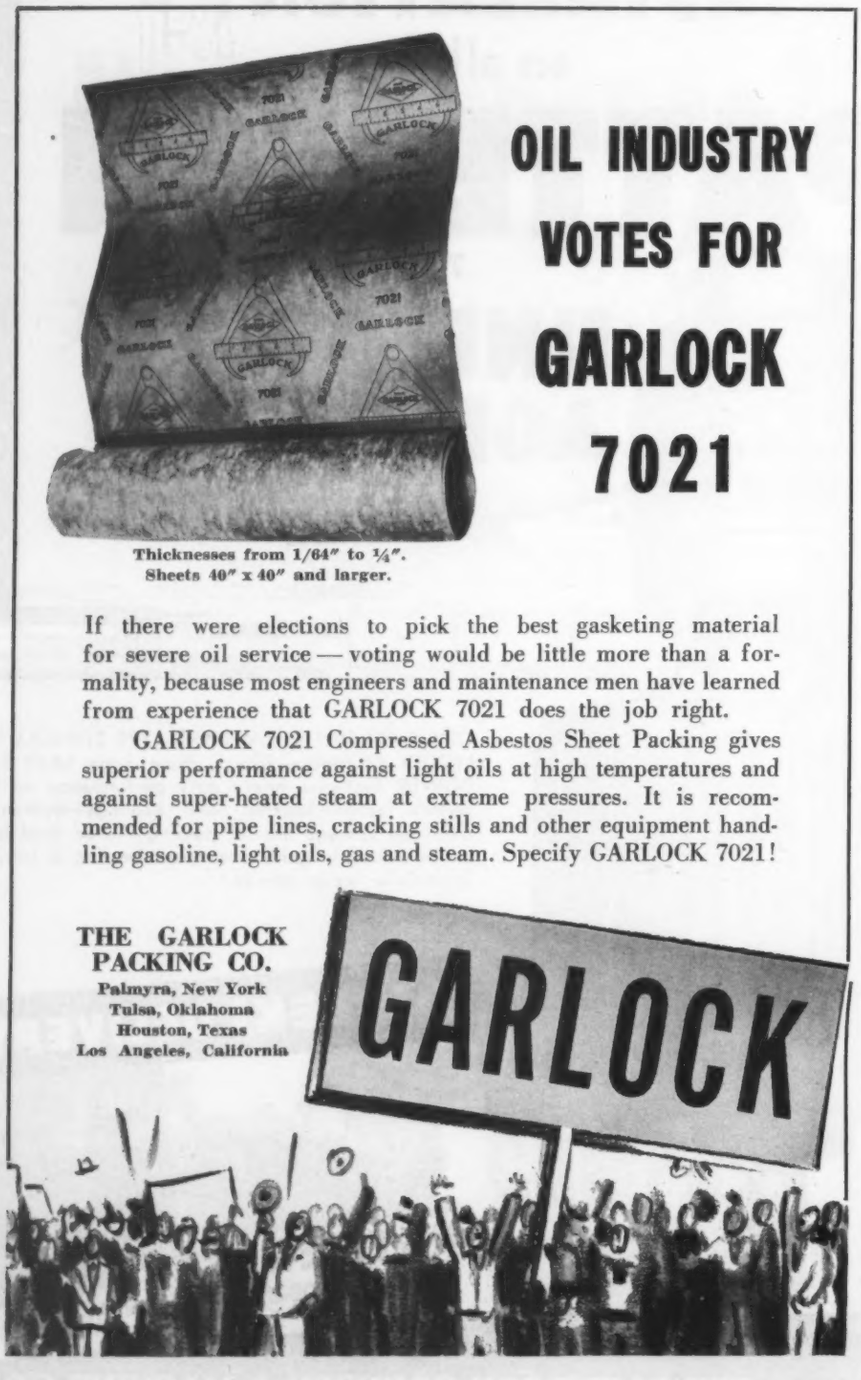
### Group's Ownership

The defendant companies were said by the department to own or control at the present time 60 percent of the investment in the industry, 68 percent of the crude-oil reserves, 50 percent of the production of crude oil, 92 percent of the stocks of crude oil, 79 percent of the crude-oil storage capacity, 90 percent of the imports of crude oil, 85 percent of crude-oil trunk pipe-line mileage, 96 percent of the crude transported in trunk pipe lines, 76 percent of the crude-oil refining capacity, 87 percent of the cracking capacity, 85 percent of gasoline production, 95 percent of gasoline exports, 96 percent of gasoline pipe line mileage, 87 percent of the dead weight tonnage of oil tankers, 88 to 93 percent of the stocks of the principal petroleum products and 75 percent of all the bulk plants and service stations.

"This proceeding is being instituted under the department's policy of taking up in a single investigation or proceeding all of the restraints which affect the distribution of a product from the raw material to the consumer," it was explained. "Only in this way can economic results be achieved. Piecemeal prosecutions against segments of an industry are both costly and inconclusive. They do not raise the fundamental issues which the court should decide, and therefore do not clarify the law. They allow restraints of trade to flourish, in one segment of the industry while they are being prosecuted in another.

"In the past 10 years, the department has been flooded with complaints from independents and consumers against various practices in the oil industry. These complaints have resulted in a series of piecemeal prosecutions in all of which the government has been successful. Yet in spite of the success of these prosecutions, the complaints continue, prices are still inflexible, independent enterprise is still under a handicap, because the cases applied only to segments rather than to the entire structure of the industry.

"For this reason the present action is brought. It will eventually present to the Supreme Court of the United States for final decision all of the issues with



OIL INDUSTRY
VOTES FOR
GARLOCK
7021
Thicknesses from 1/64" to ¼".
Sheets 40" x 40" and larger.
If there were elections to pick the best gasketing material for severe oil service — voting would be little more than a formality, because most engineers and maintenance men have learned from experience that GARLOCK 7021 does the job right.
GARLOCK 7021 Compressed Asbestos Sheet Packing gives superior performance against light oils at high temperatures and against super-heated steam at extreme pressures. It is recommended for pipe lines, cracking stills and other equipment handling gasoline, light oils, gas and steam. Specify GARLOCK 7021!
THE GARLOCK PACKING CO.
Palmyra, New York
Tulsa, Oklahoma
Houston, Texas
Los Angeles, California
GARLOCK

WATER LEVELS THAT MEET YOUR EYE . . .

A broad red line permanently fused into the wall of the "PYREX" Broad Red Line Gauge Glass is responsible for greatly increased visibility. But actually, there is *more* to these gauge glasses than meets the eye.

Machine drawn to rigid dimensional specifications, "PYREX" Gauge Glasses are easier to install and installation strains are avoided; superior chemical stability resists the solvent action of steam; mechanical strength and resistance to sudden temperature changes reduces breakage to a very minimum.

If you want gauge glasses that give accurate liquid level readings at a glance and offer true economy in the long run, specify "PYREX" Broad Red Line Gauge Glasses. "PYREX" and Corning Gauge Glasses are stocked by leading steam and mill supply houses. Corning Glass Works, Corning, N. Y.

CORNING
Glass Works
Corning, New York

**Pyrex Gauge Glasses**

respect to the reasonableness of the present vast combinations in the production, transportation, refining and distribution of petroleum products."

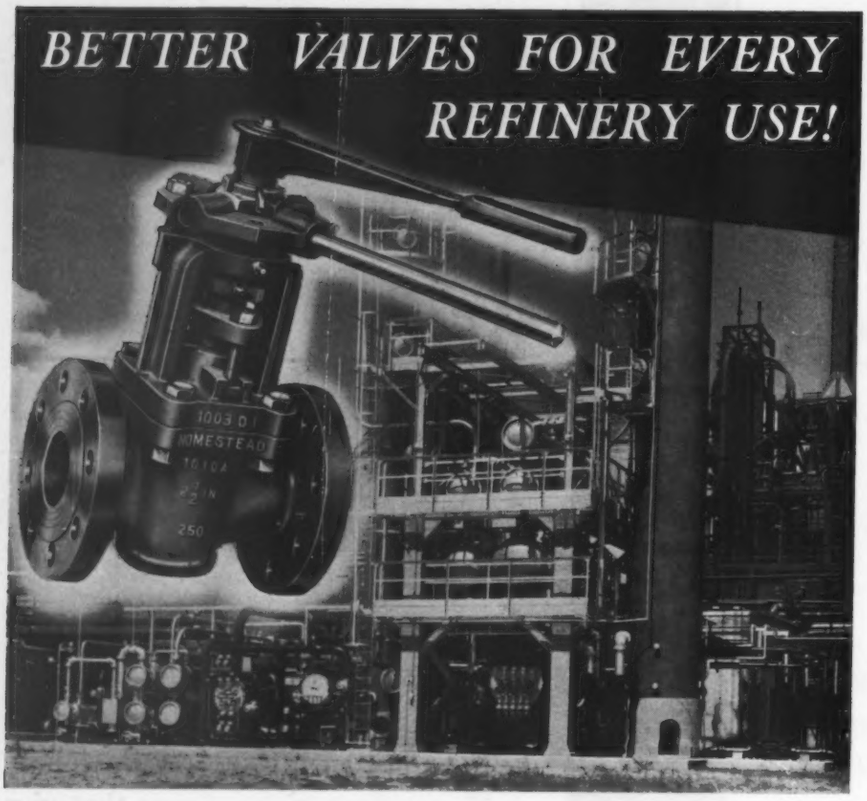
The "emphasis" of this action, it was asserted, is not only "on the interests of independents but on the interests of consumers who have not as yet benefited from the recent successful prosecutions in the Ethyl Gasoline case and the Madison oil case."

### "Unreasonable" Power

"It is believed that the great advances and technological improvements in the oil industry are not being passed on to consumers because of a wasteful, inefficient distribution system which leads to excessive prices," the department said. "Through their domination of all phases of the industry the major companies have created a system which has led to identical policies with respect to price and the suppression of free and independent enterprise. That system has given the consumer a wasteful and uneconomic distribution of gasoline, fuel oils, lubricants and kerosene. It has eliminated competing enterprise. It has destroyed the opportunity for new enterprise and capital to enter the field. It has established a small group of individuals in control of a $15,000,000,000 industry under a system where there is no incentive to compete among themselves and every incentive to prevent the entry into the market of those who would otherwise sell to consumers at lower prices. This system has closed the door to any new initiative in the oil industry which might disturb the settled policies with respect to production, transportation, refining and marketing.

"The unreasonable power possessed and exercised by the integrated companies has deprived the consumer of natural advantages due to location. It has taken from the consumer the opportunity to purchase a variety of products. It has withheld from the consumer the benefits of technological improvements which should be reflected in lower costs. It has fostered and preserved an uneconomic, duplicative, and wasteful marketing system. And finally, the power of the integrated companies has determined the production of oil, necessary for the safety of the Nation, not on true conservation principles, but on the principle of price maintenance."

If the department succeeds in the suit, it was predicted, "independent producers should receive higher prices for their crude oil, and independent refiners should be able to compete with the major oil companies. With competition restored to the oil industry, gasoline, fuel oils, kerosene and lubricants should be sold at lower prices to the consumer who should then receive the benefits of technological improvements, and the opportunity to purchase a variety of products. Lower prices for petroleum products are of great importance to the government in its defense program. Finally the production of oil should then be determined not on the basis of price maintenance but on true conservation principles."


The full line of Homestead "Lever-Seald" and "Cam-Seald" Plug Valves is *specifically designed* to meet and master temperature, pressure and corrosive service conditions of the modern Refinery. Their straight-thru flow, protected seating surfaces, positive sealing, and quick operation, even under the heat and pressure conditions of Catalytic Refining, assure unusually long life with lowest maintenance. One prominent Refiner's report, that thirty 4″ and 8″ Homestead Switching Valves are still going strong after eleven years service on temperatures up to 1120°F. and pressures to 200 pounds, is typical of hundreds of records of Homesteads' low-cost-per-year valve service. It will pay you to specify "Homesteads" on your next valve order.

Send for Valve Reference Book No. 38; and for special quantity prices on your valve requirements.

HOMESTEAD VALVE MFG. COMPANY
P. O. BOX 16, CORAOPOLIS, PA.

HOMESTEAD VALVES


## *Indiana Standard Target in First Elkins Act Prosecution*

First of three test cases which Attorney General Robert P. Jackson said would be filed against pipe-line companies was brought against Standard Oil Company of Indiana in the Federal District Court in Hammond, Indiana, October 2, charging violation of the Elkins Act.

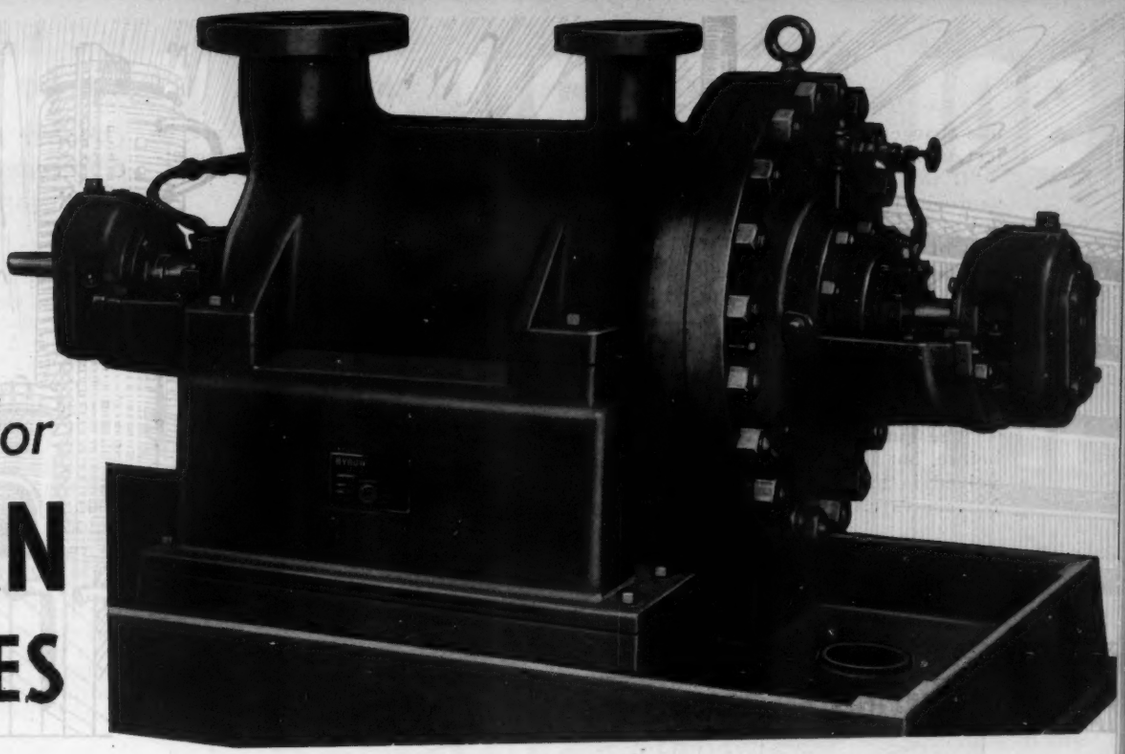
The act prohibits return of part of a purchase price to the original seller by the buyer, and has been on the statute books since 1903. Known as the anti-rebate act, it has seldom been enforced.

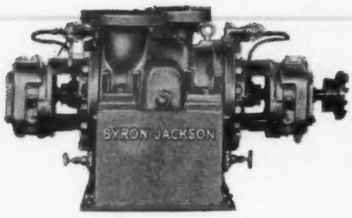
Attempted application of the Elkins law to pipe-line companies is the first effort which has been made to deal with the situation in this manner, although it has long been contended by independent oil interests and agreed by the Department of Justice that the law is sufficiently broad to cover the rebates which the owning oil companies are alleged to have received from their pipe lines.

Representatives of the company explained that Stanolind Pipe Line Company, a wholly owned subsidiary, constitutes merely a plant facility for transporting crude oil from the producing fields to refineries. As such, it was maintained, it has accumulated no profits in the usual meaning of the word, although Standard has paid transportation charges at rates approved by the Interstate Commerce Commission.

The surplus cash accumulated by the pipe line company has from time to time been returned to the parent company in dividends, and both the pipe

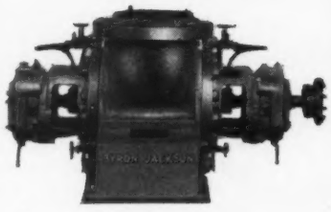
# HERE ARE *Streamlined* PUMPS *for* MODERN REFINERIES





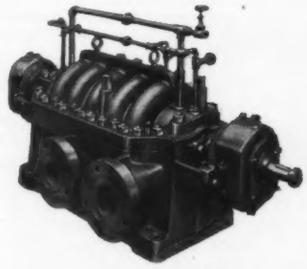

### BYRON JACKSON VC 2-STAGE HOT OIL PUMPS

Circular center suspension, concentric with the shaft, permits Byron Jackson VC Pumps to operate without expansion misalignment handling hot oil at temperatures up to 850 degrees F. The 2-stage unit, illustrated, is designed for capacities from 20 to 5,500 g.p.m., against heads up to 900 feet. Made also in a single stage type for similar capacities against heads to 450 feet.



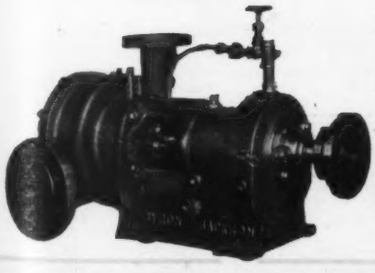
### BYRON JACKSON SINGLE STAGE DOUBLE SUCTION HOT OIL PUMP

For high capacity against low or medium heads, the Byron Jackson Single Stage Double Suction Pumps have won world-wide acceptance. By supporting the shaft at the center line free expansion is allowed without distortion. Their field of application ranges from 800 to 3,000 g.p.m., at temperatures up to 800 degrees F., against heads to 800 feet.



### BYRON JACKSON MULTIPLEX PUMPS

. . . . ideal for cold or warm oil service. Precision workmanship and rugged construction assure users of these pumps long, trouble-free service. Capacities range up to 75,000 barrels per day against pressures up to 1,200 lbs. per square inch.



### BYRON JACKSON BM PROCESS PUMPS

. . . have only one stuffing box—a simplicity of design attainable only with overhung impeller construction. As this stuffing box operates at slightly greater than suction pressure, the unit is well adapted to vacuum service. Where the material being pumped is difficult to hold in a stuffing box, this unit with its single stuffing box, possesses a decided advantage. These pumps are available for capacities from 10 to 7,000 g.p.m. at heads from 20 to 500 feet.

## MEDIUM PRESSURE DOUBLE CASE HOT OIL CHARGING PUMP

This new pump is ideal for "medium pressure" service where pressures are too high for a pump of single case construction, but not high enough to require the well known Byron Jackson Type HO Pump.

The exacting requirements of hot oil charging are fully met by the Byron Jackson Type MHO Pump. Both stuffing boxes are under low pressure; the number of parts is held to a minimum; chrome alloy steels are used to resist coking, corrosion and erosion. The horizontally split inner case permits assembly of the complete rotating element in the shop, as a separate unit. No other pump of double case construction has the accessibility of the Byron Jackson Type MHO or HO Pumps.

## BRIEF SPECIFICATIONS TYPE MHO

*Description:* Horizontal, split, inner volute case supported by and surrounded by outer case, with pumped liquid at discharge pressure in the space between inner and outer case. Single, circular, flanged joint with metallic gasket forms the only high pressure external joint in the pump. Water jacketed stuffing boxes have to seal against suction pressure only. Inner volute split case feature permits complete assembly of rotating element in the shop, with minimum possible field work. *Application:* Hot oil charging, hydraulic press, and any hot liquid, high pressure pumping. *Standard Materials:* Cast steel outer case; nickel cast iron or chrome alloy steel inner case. Chrome alloy steel, Stellited, on wearing surfaces for trim. Material variations are made according to service conditions. *Capacity Range:* 150-900 g.p.m. *Head Range:* Up to 2,000 ft.

*DETAILED BULLETINS ARE AVAILABLE UPON REQUEST*

Dept. O-15

**BYRON JACKSON CO.**

420 Lexington Ave., NEW YORK, N. Y., U. S. A.
2150 E. Slauson Ave., LOS ANGELES, CALIFORNIA, U. S. A.

*Established 1872*

# BYRON JACKSON

**CENTRIFUGAL PUMPS FOR EVERY SERVICE**

line charges and the dividends are subject to taxes.

"If the pipe line company were organized as a department of the Standard of Indiana there would be no question of rebate because there would be no dividends," it was contended by Buell Jones, counsel for the company. "If dividends paid under the circumstances herein mentioned are found to be a rebate it will be in a very new and revolutionary construction of the Elkins Act.

"The question has never been raised before, but if such payments as are involved in this case should be held to be rebates under the Elkins Act, then many other parent companies are in for prosecution as the result of accepting dividends from companies which they own in whole or in part."

Recent studies by the Interstate Commerce Commission showed that in 1938 there were 58 interstate oil pipe line carriers which paid a total of $79,388,389 in dividends, of which $36,307,568 was paid from accumulated surplus. All but a few of these companies operated as subsidiaries of oil companies.

---

R. S. Bridier, Bradford Oil Refining Company, Bradford, Pennsylvania, has been appointed to membership on the American Petroleum Institute's committee of refinery inspection.

## *October Demand 6 Percent Off*

With exports due to continue at a low level, the Untied States Bureau of Mines last month forecast that 3,580,600 barrels of domestic crude oil per day would be required to meet market demand in October, 43,700 barrels, or 1 percent under the estimate for September and 6 percent under the actual demand in October, 1939.

Reports from principal shippers, the bureau disclosed, indicate that for the coming month exports of motor fuel will be approximately 1,600,000 barrels, the same as in September but less than half the exports of October of last year, while shipments of crude oil will approach 3,900,000 barrels, also the same as in September but 3,000,000 barrels under the October, 1939, total.

Daily average crude production during the four weeks from August 10 to September 7 was 3,538,000 barrels, and runs to stills for the same period were 3,518,000 barrels, the bureau reported. During the period, domestic crude stocks declined an average of 50,000 barrels daily, indicating a demand of 3,588,000 barrels.

"The reduction in crude demand during the third quarter of 1940 represents a reaction from the relatively high operations of the second quarter and reflects evidence of further declines in the export markets for refined products due to the pressure of foreign oils that have been left without a market by the blockade of European ports," it was explained.

"The fuel-oil situation has become easier due to a smaller increase in domestic demand that was anticipated and to the expectation of decreased exports and larger imports," the bureau commented. "Stocks of distillate fuel oil have reached a point about 7,000,000 barrels above a year ago, which indicates the possibility of a further curtailment in crude runs during the winter months. This would automatically help to correct the gasoline inventory situation. It may be possible to keep gasoline stocks at a practically stationary level during the last quarter of 1940 as compared with the abnormal increase of almost 12,000,000 barrels in the same period of 1939."

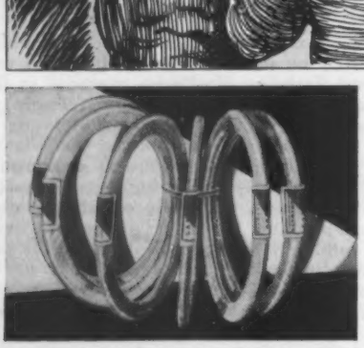
Domestic demand for motor fuel in October was estimated by the bureau as 53,000,000 barrels, or 7 percent higher than the actual for the corresponding month last year.

A reduction of 2,100,000 barrels in stocks was foreseen, the bureau pointing out that stocks of finished and un-

**Bureau of Mines Forecast of Crude Oil Demand for October**

| State | Forecast Oct., 1940 | Forecast Sept., 1940 |
|---|---|---|
| Texas | 1,305,200 | 1,320,000 |
| California | 583,200 | 593,000 |
| Illinois | 405,200 | 430,000 |
| Oklahoma | 403,500 | 397,000 |
| Louisiana | 274,200 | 274,700 |
| Kansas | 178,700 | 170,700 |
| New Mexico | 104,500 | 105,300 |
| Wyoming | 75,200 | 75,300 |
| Arkansas | 70,700 | 69,700 |
| Michigan | 53,900 | 55,700 |
| Pennsylvania | 45,100 | 47,600 |
| Montana | 17,700 | 17,700 |
| New York | 12,000 | 13,700 |
| Kentucky | 12,200 | 13,300 |
| Mississippi | 9,000 | 9,700 |
| Indiana | 9,300 | 9,300 |
| West Virginia | 9,100 | 9,000 |
| Ohio | 8,000 | 8,300 |
| Colorado | 3,900 | 4,000 |
| | 3,580,600 | 3,624,300 |


KEEPING 'EM ROLLING By WESTCOTT



J-M KEARSARGE BOILER GASKETS: Form lasting tight seals on handholes, manholes and tube plates.

**P.S. THEY DID!...with tougher, tighter-sealing J-M Kearsarge Boiler Gaskets**

FREQUENT tie-ups for packing or gasket replacements cost plenty in wasted time and idle equipment. Yet much of this expense can be saved by materials built to stand up longer. The next time you have a replacement job, try J-M Packings and Gaskets and you'll find out what real packing economy means. For details on the complete J-M line, write for the J-M Packing Catalog. Johns-Manville, 22 E. 40th St., N. Y., N. Y.

JM PRODUCTS

JOHNS-MANVILLE PACKINGS & GASKETS

THERE'S A DISTRIBUTOR NEAR YOU

# NO PRESSURE VESSEL JOB *Is Too Big for* SMITH

**HUGE BUTANE TOWER**—measuring 144'-7¾" in length by 10'-0" in diam., weighing about 115 tons. This photograph shows the record-size tower in one of the stages of being erected.

THIS huge pressure vessel, towering nearly 145 feet into the sky, was built for one of America's great refineries by A. O. Smith. In size it is typical of other pressure vessels now under construction in the Smith plant—some of them with diameters as great as 18 and 20 feet. Many of these vessels are completely finished in the Smith plant; some are built in sections and shipped knocked-down for erection in the field. Many are Smithlined with various alloys for different service requirements.

The petroleum refining industry turns to Smith for a large portion of its pressure vessels, because Smith's facilities for the construction of such vessels are unequaled . . . and because the Smith method of dealing with corrosion problems *individually* has proved to be the most satisfactory.

A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at: New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Los Angeles.

## DID YOU KNOW?

- A. O. Smith, founded in 1874, is the *largest producer* in the world of big, single-piece, glass-lined tanks.
- Brewery stock houses, equipped with glass, are now far more *economical* because of Smith contributions.
- Among these contributions is the *Smith blue glass*—smooth and lustrous, simplifying cleaning—the ultimate in sanitation.
- 5000 Smith craftsmen, in an ultramodern 125-acre plant, produce *50 million pounds of steel products* monthly.

# A.O.SMITH CORPORATION

*Milwaukee, Wisconsin*

PIONEER MANUFACTURERS OF ELECTRIC-WELDED

*Pressure Vessels*

*Casing · Line Pipe*

call CORBETT-WALLACE

for YOUNGSTOWN

PIPE

TAYLOR Forged Steel Flanges and Fittings • POWELL Valves • YOUNGSTOWN Pipe • PETRO Unions and Checks • GLOBE Boiler and Condenser Tubes • LAMSON & SESSIONS Rivets • EAGLE PICHER Insulation • STEEL, Structural and Plates.

*Immediate shipment from Houston stocks on all sizes of:*

**Youngstown seamless plain end pipe in standard, extra heavy and double extra heavy weights. Standard galvanized black merchant and black line pipe, T and C. Butt weld plain and extra heavy pipe.**

CORBETT-WALLACE CORPORATION

*Quality Products Plus Engineering Assistance*

SAWYER AND WINTER STREETS • HOUSTON • PHONE CAPITOL 5327

TUBE-TURNS

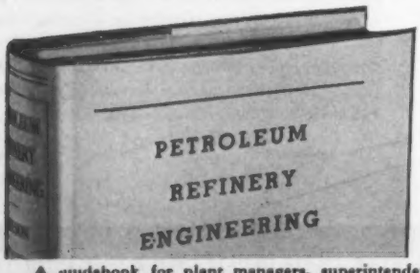
*The Original Seamless* **WELDING FITTING**

These fittings are forged from **Seamless Steel Tubing** . . . are strong, safe and easy to install. Standard and Extra Heavy Patterns are carried in our Houston stocks.

MECO

MAINTENANCE ENGINEERING CORPORATION

P. O. Box 2637 Houston, Texas, U.S.A. Phone P-3135




**Petroleum Refinery Engineering**

By W. L. NELSON

*Consulting Petroleum and Chemical Engineer*
*Professor of Petroleum Refining,*
*University of Tulsa*

**647 pages, 6 x 9, 185 illustrations**
**$6.00**

**A guidebook for plant managers, superintendents, chemists, engineers, and other refinery men. Provides a complete engineering treatment of petroleum processing, emphasizing its relation to chemical engineering. Covers fundamentals, many details of the design and operation of petroleum equipment, economical aspects, etc. Includes illustrations or examples of almost all important calculations.**

*Order from*

**Gulf Publishing Company, 3301 Buffalo Drive, Houston, Texas**

finished gasoline were 89,065,000 barrels on July 31, and, according to American Petroleum Institute estimates, about 4,450,000 barrels were withdrawn during August, leaving approximately 84,600,000 barrels at the close of the month compared with 72,335,000 barrels on August 31, 1939.

Benzol production and direct sales of natural gasoline are estimated at 1,320,000 barrels. With allowance for exports, a refinery production of 51,180,000 barrels is indicated, which is distributed among the several districts as follows, in thousands of barrels:

East Coast, 6960; Appalachian, 1820; Indiana-Illinois, 10,920; Oklahoma, 3160; Kansas, 2830; Inland Texas, 3580; Gulf Coast Texas, 12,040; Gulf Coast Louisiana, 1320; Inland Louisiana-Arkansas, 890; Rocky Mountain, 1360, and California, 6300.

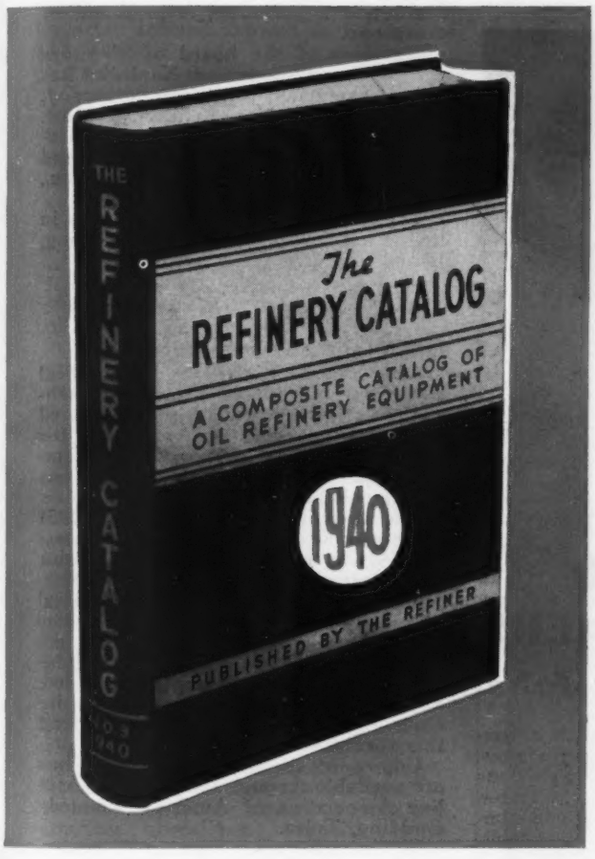
Natural gasoline to be blended at refineries was estimated at 8.5 percent of the total refinery production, or 4,350,000 barrels. The yield of straight-run and cracked gasoline was placed at 43.4 percent and, applied to the production of 46,830,000 barrels, gives crude runs of 107,900 barrels, or 3,480,600 barrels daily.

In addition to the allowance for exports, the bureau estimated that crude oil to be used for fuel and losses would increase, estimating it at 2,700,000 barrels. The total demand for domestic crude oil in October, accordingly, was placed at 111,000,000 barrels, or 3,580,600 barrels daily.

## *Technical Committees for Year Named by N.G.A.A.*

Getting ready for an active year in its technical studies, the Natural Gasoline Association of America has announced the committee lists and activities for the fiscal year of 1940-1941. According to William F. Lowe, Secretary-treasurer of the Association, chairmen and vice chairman of the principal committees are as follows: economics committee, J. R. Jarvis, Lone Star Gasoline Company, Dallas, chairman and H. E. Means, Coltexo Corporation, Monroe, Louisiana, vice chairman; gas contract committee, R. A. Worley, Parade Gasoline Company, Shreveport, chairman and John T. Oxley, Warren Petroleum Corporation, Tulsa, vice chairman; gas testing committee, H. L. Oder, Cities Service Oil Company, Bartlesville, chairman, and H. D. McLean, Hercules Gasoline Company, Shreveport, vice chairman; legal committee, Wilbur J. Holleman, Glen Rose Gasoline Company, Tulsa, chairman, and W. P. Z. German, Skelly Oil Company, Tulsa, vice chairman; research and educational committee, B. R. Carney, Shell Oil Company, Tulsa, chairman, and W. F. Fulton, United Gas Pipe Line Company, Shreveport vice chairman; specifications and outage committee, Howard E. Felt, Warren Petroleum Corporation, Tulsa, chairman, and Harry Wheeldon, Lone Star Gasoline Company, Dallas, vice chairman; technical committee, C. R. Williams, Continental Oil Company, Ponca City, chairman, and H. H. Beeson, Sabine Valley Gasoline Company, Shreveport, vice chairman; traffic committee, F. A. Shellhorn, Hanlon-Buchanan, Inc., Tulsa, chairman, and E. C. Kitching, Phillips

# FOR THOSE WHO BUY AND SPECIFY *Refinery Equipment*




**MEN WHO BUY, specify and requisition equipment and materials in refineries the world over *say they find The Refinery Catalog of genuine time-saving usefulness and value.***

**In the current edition more than two hundred leading manufacturers of refinery and natural gasoline plant equipment filed complete or condensed catalog descriptions and engineering data on their products. This information — compiled by the manufacturers themselves — is up-to-date and authentic, and is arranged for convenient usage. Thirty pages of index and cross-index make it simple for you to find what you want in a hurry.**

**You can be sure that wherever oil is refined The Refinery Catalog is recognized and used as the primary source of equipment information.**

**"The convenience of The Refinery Catalog and the fact that it contains such a wealth of equipment and process data in a single volume makes it the logical starting place in searching for information."**

**The new 1940 REFINERY CATALOG is a veritable "library of equipment and process information under a single cover."**

"YOU'LL FIND IT QUICKLY IN THE REFINERY CATALOG."

# The REFINERY CATALOG

## A COMPOSITE CATALOG OF OIL REFINERY EQUIPMENT

Petroleum Company, Bartlesville, vice chairman.

In discussing research work planned for the year, George P. Bunn, Phillips Petroleum Company, president of the association, stated the agenda was so crowded with valuable but time-consuming projects that division of work among subcommittees will be required to conclude some projects before the annual convention next spring.

"Among the more interesting activities of the technical committee," said Mr. Bunn, "is that concerned with studies of low-temperature fractional distillation apparatus and procedure. This project has been under way for some months as a cooperative study among fifteen different laboratories. Preliminary studies involving the exchange and analysis of identical gas samples are nearly completed and the work of correlation of results is about to begin under the supervision of Dr. G. G. Brown, University of Michigan and Dr. Walter J. Podbielniak of Chicago. The object of the project is to eliminate all possible sources of error in present apparatus and to standardize procedure as far as possible. It will be some months before the final report will be completed and the committee will turn to a similar investigation of fractional analysis of liquids. A meeting of interested technical men to discuss the correlations of the present studies and to plan the new phase will probably be held in Dallas late in November.

"The Gas Testing Committee will continue its studies of the present charcoal testing code for determining the gasoline content of natural gas and is working on a new method for determining the specific gravity of the high pressure gases from distillate wells. Other studies of improved methods for measuring, sampling and testing the high pressure gases in repressuring and pressuring projects are also planned for this committee."

CONSTANT TORQUE AT LOW SPEEDS PREVENTS STALLING
NO DEAD CENTERS — INSTANT PICK UP
DEVELOPS 28% MORE POWER
THE AIRETOOL MFG. CO. SPRINGFIELD, OHIO
New

**POWER SEAL in AIRETOOL CLEANERS**

***Speeds up Tube Cleaning Jobs!***

**OTHER AIRETOOL PRODUCTS**

• FLY CUTTER • TUBE JIG • POLISHING & BUFFING MOTORS • PLUG SEAT PROTECTOR • TOOL TRUCKS • CALIPERS • TUBE GAUGES

**The New "3000" Series Airetool Motors** have advantages heretofore unheard of in tube cleaning motors. The motor is made along the same lines as our previous super power motors. There are no added parts . . . three parts were improved. The same, simple slip-fitted construction still permits assembling without special tools.

**The 28% more power** developed means: no dead centers . . . motor starts as soon as air is applied . . . constant torque at low speeds prevents stalling . . . wider range of cutter head combinations can be used.

**There is an Airetool Cleaner** for every size tube and for every coke condition. Our Bulletin OR-58 describes these cleaners and other refinery specialties in detail. Send for it today.

**A new Airetool Catalyst Reactor Tube Cleaner eliminates the dangers of this tube cleaning job. Details on request.**

**AIRETOOL**

**MANUFACTURING COMPANY**

**SPRINGFIELD, OHIO**

***Representatives in principal cities***

**NEW YORK ADDRESS, 50 CHURCH ST.**


## *Michigan Refiners Form Institute*

Organization of the Oil Institute of Michigan, with refiners of the state in its membership, was completed in September. L. V. Nicholas, who once was president of the National Petroleum Marketers Association, is president of the group.

Members of the board of directors are: Walter E. Anderson, Naph-Sol Refining Company, Muskegon; Ben J. Skinner, Midwest Refineries, Inc., Grand Rapids; C. L. Maguire, Roosevelt Oil Company, Mt. Pleasant and Reid Brazell, Leonard Refineries, Inc., Alma.

The organization has headquarters in the First National Bank Building, Grand Rapids.

## *L.P.G. Specifications Revised by N.G.A.A.*

After a series of tests by its technical committee, the Natural Gasoline Association of America has issued revised specifications and test methods for liquefied petroleum gases. All are tentative and subject to revision. It was effective September 1, 1940.

The revision is the first since 1931 when the first specifications and test methods were set up. Among the major modifications in the original specifications was inclusion of a broad general specifications for butane-propane mixtures. Barometric corrections for the 95 percent boiling points of these mixtures and for butane were also added, and a total sulfur specification was included together with a test for making this specification.

Copies of the revised specifications are available through the Natural Gasoline Association of America, Kennedy Building, Tulsa.

## *Thomas Heads Rubber Concern*

R. W. Thomas, former head of the Philgas division of Phillips Petroleum Company, has been elected president of Hydrocarbon Chemical & Rubber Company, a concern recently formed by the oil company and the B. F. Goodrich Company, Akron, Ohio, to manufacture a new synthetic rubber.

Other officials of the new company are: Waldo L. Semon, vice president and director of research; Hy Boyd, secretary, and Herman P. Gangwer, treasurer.

Thomas recently moved to Bartlesville from Detroit to head the new Phillips special products department. He joined Phillips Petroleum Company as construction superintendent at Wetumka, Oklahoma, in 1926. Five months later, he was transferred to the research department as an engineer, and within a year was assistant director of research.

## *Asphalt Sales Up in 1939*

Use of asphalt, domestic and foreign, increased 8 percent in 1939 over 1938. The figures, compiled by the United States Bureau of Mines, show that refining plants in the United States had output of 4,954,400 tons in 1939, an increase of 447,500 tons over 1938. There was a decline of 2800 tons in export demand.

The increase for 1939 was recorded despite a drop for the first quarter of the year. In the first three months, demand was 9 percent less than for the corresponding period for 1938. Second quarter demand rose 11 percent, third quarter demand was also 11 percent above the previous year, while fourth quarter demand showed an increase of 13 percent.

Details of the manufacture and distribution of asphalt for the two years follow:

"Of the 1939 sales of petroleum asphalt," the bureau said, "1,278,786 short tons were made from foreign crude petroleum imported chiefly from Venezuela and Mexico, compared with 1,449,664 tons in 1938. Although runs of foreign crude to stills increased from 26,187,000 barrels in 1938 to 33,490,000 barrels in 1939, apparently more of the foreign crude was run to fuel oil in 1939 than in 1938. East Coast refineries sold 96 percent of the asphalt made from foreign crude in 1939, compared with 91 percent in 1938.

"Total sales of petroleum asphalt by refineries increased 8 percent in quantity, but decreased 1 percent in value from 1938 to 1939. The average value at the refinery of asphalt sold was $8.47 in 1939 compared with $9.24 in 1938.

"Highway construction absorbed three-fifths of all asphalt sold in 1939, in the form of paving asphalt, paving flux, cut-back asphalts, and emulsions. In general, such statistics as are available indicate an increase in street and road construction in 1939 over 1938. The increase in mileage of state highways built during 1939 over 1938, as reported by the Engineering News-Record, was in bituminous types, in untreated surfacing, and in grading and draining operations. Asphaltic types gained 7 percent from 1938 to 1939; they constituted 78 percent of the mileage of higher and intermediate types laid on state highways in 1938 and 85 percent in 1939.

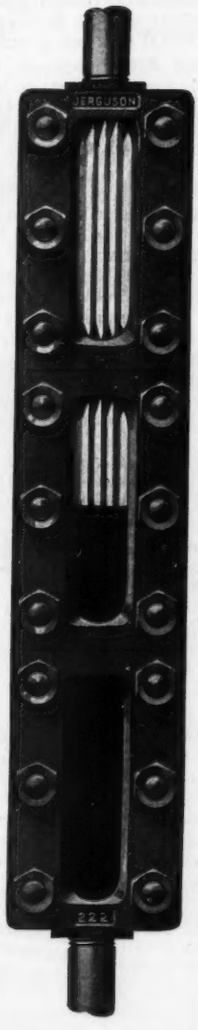
"Increased construction of lighter types of surface, both on state highways and secondary roads, as well as continued use of cut-back asphalts for soil stabilization and revetments, is indicated by a 4 percent increase in sales of cut-back asphalts, from 1,392,997 tons in 1938 to 1,454,846 tons in 1939, although the latter figure includes domestic sales only and the former figure includes export sales as well.

"Petroleum refineries sold 56,953 tons (13,417,238 gallons) of asphalt emulsions valued at $678,779 in 1938, and 55,881 tons (13,164,691 gallons) valued at $635,881 in 1939. In addition, 43,928,186 gallons valued at $3,659,258 were sold in 1938 by major industrial companies that purchased asphalt from petroleum refineries; and 49,826,902 gallons valued at $3,899,958 in 1939. Accordingly, total known sales of emulsified asphalts and fluxes increased in quantity from 57,345,424 gallons valued at $4,338,037 in 1938, to 62,991,593 gallons valued at $4,535,839 in 1939.

"Roofing manufacture furnished the second-largest demand for asphalt, absorbing 25 percent of the total sales in 1938 and 26 percent in 1939. Although shipments of prepared roofing and asphalt siding reported to the Bureau of the Census decreased slightly—from a total of 35,328,029 squares in 1938 to 34,823,305 squares in 1939—sales of roofing asphalt and roofing flux combined increased from 1,127,635 tons in 1938 to 1,229,046 tons in 1939. The latter figure, it may be noted, includes only domestic sales, while the figure for 1938 includes both domestic and export sales.

"The tonnage of asphalt (natural, by-product or petroleum) terminated by class 1 railroads in the United States increased from 4,295,232 short tons in 1938 to 4,826,245 tons in 1939, according to freight-commodity statistics compiled by the Interstate Commerce Commission. The increase was general, but more than nine-tenths of the increase occurred on railroads operating principally north of the Potomac and Ohio Rivers and east of Lake Michigan and the Illinois River.

"Imports of natural asphalt and bitumen into the United States increased in quantity from 23,645 short tons in 1938 to 26,586 tons in 1939, but declined in value from $378,209 in 1938 to $362,559 in 1939, according to data furnished by the Bureau of Foreign and


**Close-Up of a Typical Jerguson Gage—Reflex Type — most commonly used in the petroleum industry. The empty space shows WHITE while the liquid shows BLACK. Sizes range from 5" to 84" in length, in single and multiple units. Longer gages can be built in either Reflex or Transparent Types.**

# You Can Rely On

# JERGUSON

# GAGES

- **WHATEVER THE LIQUID;**
- **WHATEVER THE PRESSURE;**
- **WHATEVER THE TEMPERATURE;**
- **WHATEVER THE VARIATION IN LEVEL;**

***In other words, whatever your gage problem, there usually is a Jerguson Gage that will take care of it.***

Where requirements are special, as they sometimes are, special materials are employed and designs are created to meet the special specifications. This company has been engaged in studying, developing, and building Jerguson Gages for more than 30 years. Any special problem you may have will be given our immediate and best attention.

Jerguson's principal products are shown and described on pages 178 and 179 of the latest Composite Refinery Catalog. Unless your requirements are special you can very likely order directly from that catalog.

**FILL IN and MAIL—you will hear from us promptly**

**JERGUSON GAGE & VALVE CO.**
**87 Fellsway, Somerville, Mass.**

Without obligating us in any way we shall be glad to have your suggestions regarding_____ *(give number)* gages for handling_____ *(oil, gasoline, etc.)* at_____ lb. per sq. in. Liquid level varies_____ inches, and gage should be at least_____ inches high. Without climbing, attendant will be_____ ft. away from the gage. The color of the liquid is_____ *(clear, red, etc.)*

☐ Please send catalog. ☐ Please send representative.

REMARKS_____

NAME_____

FIRM_____

STREET_____

CITY_____ STATE_____

Domestic Commerce, Department of Commerce. Imports of lake asphalt from Trinidad increased from 19,396 tons valued at $205,038 in 1938, to 21,440 tons valued at $227,223 in 1939. Imports of grahamite from Cuba likewise increased, from 3826 tons valued at $65,344 in 1938 to 4676 tons valued at $83,734 in 1939. Atlantic Coast ports (chiefly New York) received 23,188 tons of natural asphalt and bitumen and Gulf Coast ports (Mobile, New Orleans, and Galveston) 3364 tons in 1939.

"Imports of petroleum asphalt, including cut-backs and road oil, increased from 9786 short tons valued at $38,883 in 1938, to 47,261 tons valued at $189,052 in 1939. All of the petroleum asphalt imported in 1939 came from the Netherlands West Indies, 37,763 tons were received in the customs district of New York and 9498 tons in the customs district of New Orleans.

"Exports of petroleum asphalt, manufactured and unmanufactured, reported by the Bureau of Foreign and Domestic Commerce, were 1 percent less in 1939 than in 1938. They totaled 202,499 tons valued at $3,030,162 in 1938, and 199,695 tons valued at $3,097,799 in 1939. The principal decreases were in shipments to Europe, especially to the United Kingdom, France and Belgium. Less asphalt was exported to other North American countries and to South American countries (except Brazil) in 1939 than in 1938. On the other hand, more asphalt was exported to eastern Asia, especially to the Netherlands East Indies, British India and French Indo-China; to Africa, especially the Union of South Africa; and to Australia in 1939 than in 1938; but these increased exports were insufficient to offset the decline in shipments to northwestern Europe.

"As a result of decreased demand east of the Mississippi River, sales of bituminous rock by producers in the United States decreased from 449,091 short tons (revised figure) in 1938 to 422,484 tons in 1939. The value of the rock asphalt sold decreased from $2,219,159 (revised figure) in 1938 to $2,007,810 in 1939. Rock-asphalt operators in Kentucky and Alabama sold 215,142 tons valued at $1,379,138 in 1938, but only 175,602 tons valued at $1,214,476 in 1939. On the other hand, sales by operators in Texas, Oklahoma and New Mexico increased from 206,443 tons (revised figure) in 1938, to 221,497 tons in 1939, but declined in value from $727,032 in 1938 to $684,808 in 1939. Sales by producers in California and Kansas were lower in both quantity and value in 1939 than in 1938, but sales in Missouri were slightly higher both in quantity and in value."

## *Stoddard Solvent Bulletin Issued*

Specifications for Stoddard Solvent, dry cleaning fluid, as revised under a voluntary standard of the trade and approved by the United States Department of Commerce has been printed by the department. It is listed as Commercial Standard CS3-40 and is available through the Superintendent of Documents at Washington for 5 cents a copy.

# ▼ PLANT ACTIVITIES ▼

**Humble's Toluol Plant:** Preliminary steps toward construction of a $12,000,000 plant for manufacture of toluol, used in the manufacture of explosives, at Baytown, Texas, were taken at Washington last month by officials of Humble Oil & Refining Company and national defense officials.

The company has been authorized to proceed with acquisition of a site, materials and equipment pending completion of a formal agreement. Funds for the plant, which will be constructed on a 50- to 60-acre site adjoining the company's Baytown refinery, will be provided by the federal government on the national defense amortization plan. Construction is expected to take a year, and output of the plant will be between 25,000,000 and 30,000,000 gallons a year.

Announcement of the proposal to manufacture toluol was first made in The Lamp, publication of Standard Oil Company of New Jersey, of which Humble Oil & Refining Company is a subsidiary.

"The form of contract submitted by the Humble company is similar to several contracts already entered into by the government for the manufacture of munitions," the announcement said. "Under such a contract, Humble would erect and operate a government plant at cost plus a fixed management fee, or on the same basis would operate a plant previously constructed by the government. The fixed management fee and charges to cover indirect expense not susceptible of appraisal in advance are not stated in Humble's offer, but are left open for determination by the government in keeping with its policy in such matters.

"If the government finds it necessary to provide itself with new sources of this all-important war material, it can recover some toluene in the production of high-octane gasoline. If larger quantities are required they can be obtained synthetically."

**Desulfurization for McNutt:** C. E. McNutt, refinery manager for McNutt Oil & Refining Company, has announced completion of a 500-barrel-per-day Perco catalytic desulfurization plant, which is currently processing Ward County, Texas, straight-run gasoline. Total sulfur reductions are of the order of 90 to 95 percent.

**Sweetening at Lake Charles:** Continental Oil Company will construct a 4000-barrel per day liquid process type Perco copper sweeting unit at its refinery now under construction near Lake Charles, Louisiana.

**Ashland Increases:** A $650,000 program for expansion of its plant and river transport facilities was announced last month by Ashland Oil & Refining Company. The company's refinery at Cattlettsburg, Kentucky, will receive a $350,000 addition to boost its present 10,000-barrel distilling capacity by 25 percent and gasoline output from 3500 to 6000 barrels. A $250,000 towboat and two 9000-barrel barges to cost $50,000 are being added to river transport facilities and will serve a new territory as far as Pittsburgh.

**Louisiana Tax Exemptions:** Standard Oil Company of Louisiana on October 1 was granted 10-year tax exemptions on a $3,000,000 catalytic cracking unit and on a $2,800,000 synthetic rubber plant, both under construction at Baton Rouge. Work on the refinery unit has just started, while the first unit of the rubber plant is scheduled to begin operation about March 1 and the remainder by May 1.

**Wynnewood Plant Resumes:** Cosco Refining Company planned to resume operations at its plant at Wynnewood, Oklahoma, using crude furnished by Skelly Oil Company and Cox & Hammon, Inc. The plan has a capacity of 2000 barrels a day, principally road oil, asphalt and fuel oils, and products will be distributed by Skelly Oil Company.

**Small Wyoming Plant:** Albany Oil & Refining Company has been organized to construct a 100-barrel skimming plant a mile north of Laramie, Wyoming. Officers of the company are N. A. Swenson, president; H. N. Roach, vice president; H. N. Horton, secretary-treasurer; H. H. Metzger, sales manager, and E. J. Nininger, general manager.

**Propose Mississippi Plant:** H. M. Prince, Jackson, Mississippi, plans a combination topping, cracking and reforming plant at Yazoo City, Mississippi, to process crude from the nearby Tinsley field.

**Improvements at Scottsbluff:** Terry Carpenter, Inc., operating a 1700-barrel plant at Scottsbluff, Nebraska, including a 700-barrel cracking unit, plans an expansion program costing $50,000.

**Coastal Improves:** A recently acquired site adjacent to its plant at Port Isabel, Texas, was being cleared and graded by Coastal Refineries, Inc., preparatory to construction of a tetraethyl-lead blending plant and additional storage tanks. The plant has a daily capacity of 6000 barrels.

**Recycling in Sejita:** Standard Oil Company of Texas is reportedly making contracts with lease, royalty and land owners in the Sejita field, Duval County, Texas, preparatory to constructing a recycling and natural gasoline plant.

**Davis Opening Delayed:** Operation of W. R. Davis, Inc.'s $1,000,000 recycling plant in the Alice field of Southwest Texas was delayed by cratering of a water well in the plant yard caused by a nearby wild gas well. Workmen were expected to complete cleaning mud and water from the plant buildings and yard in time to start operations by mid-October.

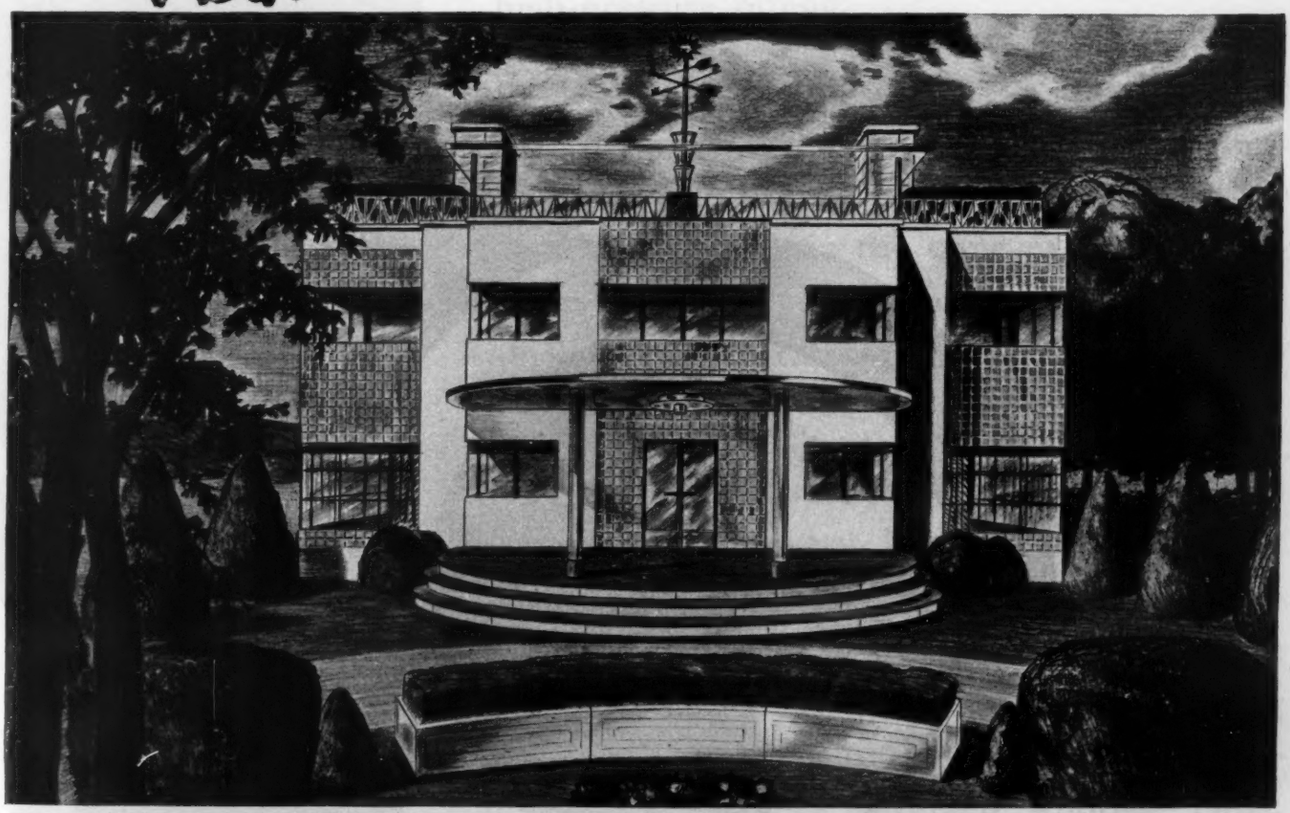
**Complete at Mid-Continent:** A modernization program involving $1,000,000 of new equipment for producing motor fuel has been completed at the West Tulsa plant of Mid-Continent Petroleum Corporation.

# "WHAT! GLASS HOUSES?"

*Suppose some one who lived forty or fifty years ago—say one of the founders of Mathieson—could pay us a visit today. And suppose we could have the pleasure of showing him the sights of 1940, of explaining the vast changes that have taken place since the turn of the century. What do you think would amaze the old gentleman most? If he were one of the pioneers who founded Mathieson, we believe he would be most interested in the revolutionary changes wrought by chemical progress and in the part his successors have played in building the present-day America. We would go about telling him the story as we tell it in this series of advertisements.*

● **Yes, Mr. M., nowadays we have houses in which glass plays a large part both in construction and decoration. Glass brick represents only one of the new ways in which the modern world utilizes glass. We use glass insulation in our homes, too. Modern decorators are producing beautiful interiors through the use of glass in decoration. Safety glass is a modern idea; our automobiles ("horseless carriages" to you, old friend) are now equipped with this cleverly constructed, shatterproof glass. The manufacture of plate glass, the last word in modernity in your day, has undergone great changes, together with window glass and glass containers of every description. And last but not least, beautiful fabrics made from spun glass are now available for a variety of purposes.**

**Your successors at Mathieson are proud of their part in the growth of the great modern glass industry. They have continued to pioneer, seeking improvements in the production and distribution of Mathieson Chemicals — products whose purity and uniformity are so highly valued by leading glassmakers and other important consumers of industrial chemicals.**



## MATHIESON CHEMICALS

SODA ASH . . . CAUSTIC SODA . . . BICARBONATE OF SODA . . . LIQUID CHLORINE . . . BLEACHING POWDER . . . HTH PRODUCTS . . . AMMONIA, ANHYDROUS and AQUA . . . FUSED ALKALI PRODUCTS . . . SYNTHETIC SALT CAKE . . . DRY ICE . . . CARBONIC GAS . . . ANALYTICAL SODIUM CHLORITE

THE MATHIESON ALKALI WORKS (INC.)
60 E. 42ND STREET, NEW YORK, N. Y.

# TUBE-TURNS for

**14½" O. D. carbon-molybdenum Tube-Turn with 1¾" wall, for power-plant service at 1500 pounds W.S.P. at 903°F.**

# "TOUGH STUFF"!

● **The big boy at left, Gentlemen, is a pretty good example of what we can do in the way of making Tube-Turns for the toughest sort of high-pressure piping.**

**But even more impressive, *we* think, is the fact that *all* Tube-Turns—from light-gauge elbows, on up to the biggest, heaviest specials—are made by exactly the same exclusive Tube-Turn process, and give you exactly the same qualities of strength, economy and dependability in your welded piping.**

**Because of their unapproached records of successful use in every line of industry, most engineers *prefer* Tube-Turns. That preference is deserved. If you want to know how fully it is deserved, read the new Tube-Turn Catalog and Data Book No. 109. Ask your distributor for a copy, or write us direct. Address: Tube-Turns, Incorporated, Louisville, Kentucky.**

# 16 YEARS OF CONSISTENT LOW COST PRODUCTION

In 1924—16 years ago—Gray Clay Treating Units were first placed in commercial operation.

Since that time Gray Clay Treating acceptance has increased until today it is widely used by all classes of refiners. That's largely because it consistently fits the requirements of refiners for economically treating gasolines in conjunction with a large variety of cracking processes.

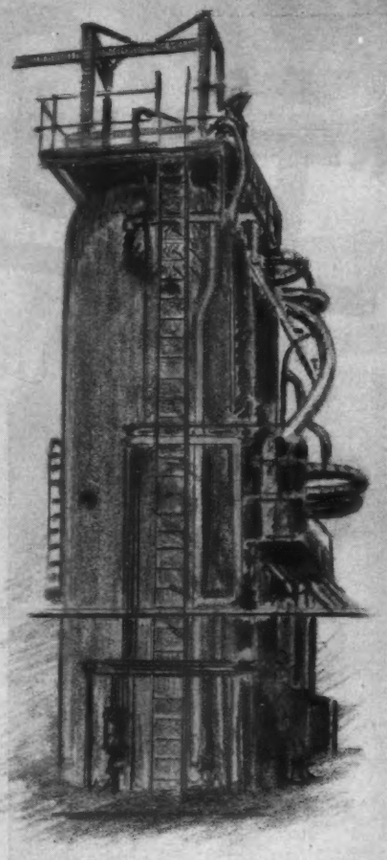
Gray Clay Treating Units will produce low gum content gasoline without loss of octane number. They will last throughout the life of the cracking unit. Often, when new cracking units have replaced old ones, the Gray Process has again been chosen to treat the gasoline.

In these days, the refiner striving for low cost production, will do well to consider the Gray Process. Moderate installation costs, negligible operating labor expense, low cost of adsorbent, minimum maintenance, are all definite economic advantages.

**THE GRAY PROCESSES CORPORATION**

*Licenses granted under United States and Foreign Patents by The Gray Processes Corporation*

**26 JOURNAL SQUARE · JERSEY CITY, NEW JERSEY**



## OVER 7 MILLION BARRELS

**In 1926 a certain refiner installed a small Gray Clay Treating Unit. To date this unit has produced 7,655,000 barrels of low gum content gasoline.**

GRAY CLAY TREATING

# SCIENCE AND TECHNOLOGY

*Abstracts prepared in co-operation with the*

**REFINER AND NATURAL GASOLINE MANUFACTURER**

*by*

**THE LESLIE LABORATORIES**

**Traver Road, Ann Arbor, Mich.**

***under the supervision of***

**DR. E. H. LESLIE and DR. H. B. COATS**

*The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.*

*Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.*

## Fundamental Physical and Chemical Data

**Phase Equilibria in Hydrocarbon Systems,** B. H. SAGE, B. L. HICKS, AND W. N. LACEY, *Ind. & Eng. Chem.* **32** (1940) pp. 1085-92.

Although methane and n-butane are important components of naturally occurring hydrocarbon mixtures, little information has been available as to the phase behavior of mixtures of these hydrocarbons. Compositions and specific volumes of the coexisting phases of the methane-n-butane system were determined throughout the two-phase region at temperatures from 70° F. to 250° F. From the data obtained equilibrium constants for methane and n-butane were computed and are reported as functions of state. From other unpublished data the fugacities of the components in the coexisting phases were established. Purification of the materials, and the methods of procedure used in the work are described. Data are presented in detail in both tabular and graphical form.

**Boiling Point — Molecular Weight Chart for Higher Hydrocarbons,** D. S. DAVIS, *Ind. & Eng. Chem.* **32** (1940) p. 1148.

A chart is given correlating the boiling points in degrees Centigrade at 1 mm. mercury absolute pressure of the higher hydrocarbons with their molecular weights and number of carbon atoms per molecule. The derivation of the chart is indicated.

**The Heat Capacity and Entropy, Heats of Fusion and Vaporization and the Vapor Pressure of n-Butane,** J. G. ASTON AND G. H. MESSERLY, *Jour. Am. Chem. Soc.* **62** (1940) pp. 1917-23.

The preparation and purification of n-butane are described. The heat capacity of n-butane was measured from 12° K. to the boiling point. The transition point of n-butane was found to be —165.60° C., the melting point, —189.29° C., and the boiling point —0.50° C. The heats of transition, fusion and vaporization at the boiling point were found to be, respectively 494.0 ± 1, 1113.7 ± 2, and 5351 ± 15 cal./mole. The vapor pressure of n-butane from 210° K. to the boiling point is given by the equation

$$\text{Log}_{10}P_{mm.} = -\frac{2352.900}{T} - 16.49230 \log_{10} T + 0.01111869\ T + 48.64763$$

The molal entropy of the ideal gas at the boiling point calculated from the experimental data is 72.05 ± 0.2 e.u. The molal entropies of the ideal gas and the superheated liquid at 298.16° K. are, respectively, 74.0 ± 0.2 and 55.2 ± 0.3 e.u. The data are presented in some detail in the article in both graphical and tabular form.

**The Heat Capacity and Entropy, Heats of Fusion and Vaporization and the Vapor Pressure of Isobutane,** J. G. ASTON, R. M. KENNEDY AND S. C. SCHUMANN, *Jour. Am. Chem. Soc.* **62** (1940) pp. 2059-63.

The preparation and purification of isobutane are described. The heat capacity of isobutane was determined from 12° K. to the normal boiling point. The melting point of isobutane is —159.42° C. and the boiling point is —11.72° C. The heats of fusion and vaporization at the boiling point are 1085.4 calories/mole and 5089.6 calories/mole, respectively. The vapor pressure of isobutane from 200° K. to the boiling point is given by the equation:

$$\text{Log } P_{mm} = -1716.687/T - 6.38879 \log T + 0.0024132\ T + 24.260325.$$

The molal entropy of the liquid at the boiling point is 47.94 ± 0.10 e.u. The molal entropy of the ideal gas at the boiling point calculated from the experimental data is 67.52 ± 0.10 e.u. The molal entropy of the liquid at 298.16° K. extrapolated from the experimental data is 52.09 ± 0.10 e.u. The molal entropy of the ideal gas from the experimental data at 298.16° K. is 70.43 ± 0.16 e.u. The results of the investigation indicate that there are errors in existing heat capacity data on the gas isobutane. The data are presented in some detail in tabular and graphical form.

**Critical Solution Temperatures and Aniline Points of Some Butane Hydrocarbons,** C. G. LUDEMAN, *Ind. & Eng. Chem.*, Anal. Ed. **12** (1940) pp. 446-8.

In order to extend the usefulness of the correlations of physical properties of hydrocarbons, based upon aniline points, it was necessary to determine the aniline point data for the butane hydrocarbons. Because of the low boiling points of the butanes, none of the existent methods was applicable to this work. The methods and the apparatus used are described. The aniline point of n-butane, isobutane, and isobutene were found to be 83.1°, 107.6°, and 14.9° C. respectively. The critical solution temperatures for the same hydrocarbons were found to be 84.1°, 109.0°, and 15.8° C. respectively. Aniline points and miscibility data of the paraffins and a few olefins are reviewed and presented in tabular and graphical form.

## Chemical Compositions And Reactions

**Nitrogen Compounds in Petroleum Distillates. XVIII. Isolation, Ozonization and Synthesis of 2,4-Dimethyl-8-s-butylquinoline,** L. M. SCHENCK AND J. R. BAILEY, *Jour. Am. Chem. Soc.* **62** (1940) pp. 1967-9.

The paper deals with counter-current extraction as used in the isolation of a new $C_{15}H_{19}N$ kero base, 2,4-dimethyl-8-s-butylquin-


**CONTROL CORROSION and LIVING ORGANISMS**

The Chrom Glucosates compounds developed in the HAERING laboratories are regularly used to treat millions of gallons of cooling water for corrosion and algae control. Each of the following Chrom Glucosates has a specific application.

*Acid Chrom Glucosate*
*Sodium Chrom Glucosate*
*Cupric Chrom Glucosate*
*Quachrom Glucosate*

Send your samples to our laboratories in Chicago, Wichita, Kansas, and New York City for over-night service.

**Write for our Chrom Glucosates brochure.**

*Have you investigated IN-HIB-CO, our new corrosion resistant coating?*

**D. W. HAERING & CO., Inc.**
**2308 S. WINCHESTER AVE.**
**CHICAGO, ILL.**

oline. The structure of this compound was established through chromic acid oxidation to the known 2,4-dimethylquinoline-8-carboxylic acid; ozonization, followed by ozonolysis, to yield 2-methylbutanoic acid; and synthesis from the intermediates acetylacetone and o-amino-s-butylbenzene. The ozonization products of 2,3,4-trimethyl-8-n-propylquinoline are described, and the synthesis of 2,4-dimethyl-6-s-butylquinoline and its degradation to 2-methylbutanoic acid through ozonization and ozonolysis are reported.

**Catalytic Dehydrogenation of Representative Hydrocarbons,** A. G. OBLAD, R. F. MARSCHNER AND L. HEARD, *Jour. Am. Chem. Soc.* **62** (1940) pp. 2066-9.

The catalytic dehydrogenation of representative hydrocarbons is briefly reviewed. In the dehydrogenation of a mixture of hydrocarbons such as are contained in petroleum naphtha, specific conditions obviously cannot be employed for each component. Hence, a knowledge of the relative behavior of the various hydrocarbons present, when subjected to a uniform set of conditions, is desirable. The apparatus and methods used in the work are described. Representative hydrocarbons of all classes were dehydrogenated over chromic oxide catalysts under identical high-rate, high-temperature conditions. Cyclohexanes were converted to aromatics and practically no residual products were formed. Paraffins were found to be much less readily converted than cyclohexanes, the activity of the catalyst steadily decreased, and elementary carbon was deposited. Olefins are more readily converted than paraffins, but the activity decline and carbon deposition are far more pronounced. Cyclopentanes dehydrogenate slowly, but closely resemble olefins in depositing large quantities of carbon. Simple methylated aromatic hydrocarbons are unaffected, but alkyl aromatics with longer side-chains, such as ethylbenzene, are slowly dehydrogenated to products that strongly poison the catalyst. The residue probably responsible consists of tar rather than elementary carbon.

**Formation of Formalin from Methane and Air by Direct Oxidation,** A. MATUI AND M. YASUDA, *J. Soc. Chem. Ind. Japan* **43** (1940) Suppl. Binding, pp. 117-8.

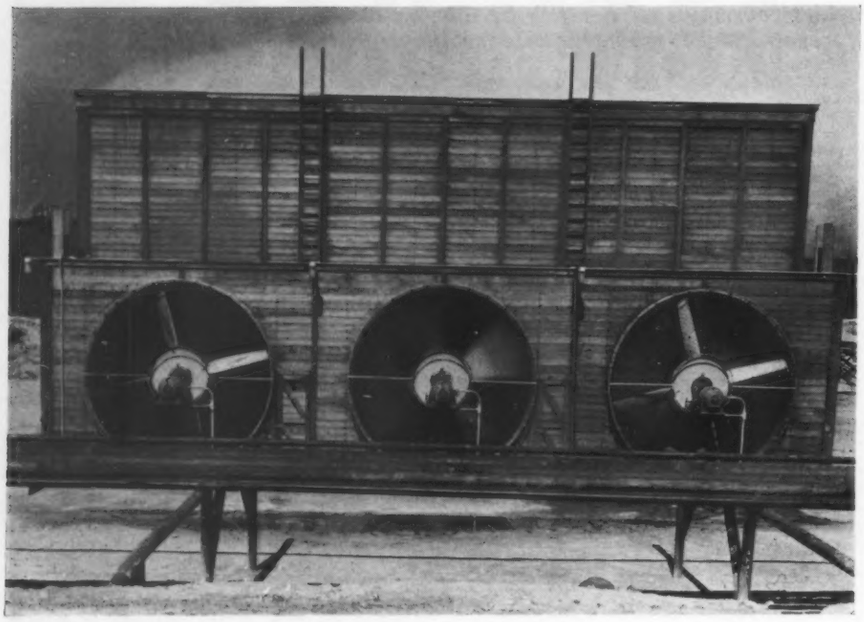
Methane from natural gas, in admixture with air in a ratio of 7:3, was oxidized by passing it through tubes of pyrex glass, quartz, porcelain and copper with $NO_2$ as gas catalyst and at temperatures of 500-700° C. Of the various catalysts studied, $UO_2$ and BeO gave the most favorable results. The data secured in the experiments are presented in tabular form.

**The Effect of Surface on Cool Flames in the Oxidation of Propane,** R. A. DAY, JR., AND R. N. PEASE, *Jour. Am. Chem. Soc.* **62** (1940) pp. 2234-7.

The investigators studied the effect of surfaces on cool flames in the oxidation of propane. A succession of cool flames occurs. Each is accompanied by a rise in pressure, and, after several seconds, a faint bluish luminescence. This spreads towards the ends of the tube and then fades in a few seconds. The phenomenon will be repeated several seconds later and at intervals until one may observe as many as eight or nine such periods of luminescence in the space of a minute or more. It was found that the cool flame region in 1:1 propane-oxygen mixtures is not materially affected by etching the reaction tube or coating it with potassium chloride. Conditions in the gas phase apparently control. Attention is called to the region of negative temperature coefficient of the rate as an effective control, leading to successive flames and preventing ignition.

**Chemistry of Fischer-Tropsch Oil Production,** K. C. APPLEYARD, *S. African Mining Eng. J.* **50** (1940) pp. 585-7, 615-17.

The use of a suitable catalyst and careful control of the reaction temperature are of the greatest importance in synthesizing liquid fuels. The primary reaction may be indicated by $CO + 2H_2 = (CH_2)_x + H_2O + 48{,}000$ calories where $(CH_2)_x$ designates a light hydrocarbon. Increasing pressure favors the formation of alcohols. Increase of hydrogen in the reaction gases favors formation of methane. Decrease of the concentration of hydrogen in the reaction gases favors formation of olefins. Increasing temperature favors the formation of methane and carbons. Iron, cobalt, and nickel, in the order named, increase saturation and lower olefin content in the reaction products. Concentration of $CO_2$ has no influence. Increase in the age of the catalyst increases the light oil fraction at the expense of the heavy oil. The raction gas, composed of carbon monoxide and hydrogen can be produced in several ways from various fuels. The procedure used will depend upon economic factors, availability of raw materials and market for by-products. It is extremely important that all forms of sulfur be removed. The most suitable catalysts, iron, cobalt, and nickel, are discussed, and the physical form in which they should be used is considered. The process is extremely flexible because of the variety of raw materials that can be used and the possible control of the products that can be made.

# Mechanical Draft Cooling Towers IN REFINERIES

Maintenance of production schedules depends upon positive control of cooling water. Lowhead, forced draft cooling towers are the most modern and effective means of meeting refinery requirements. More than 50% of the Lowhead cooling towers in service have been installed in refineries—conclusive proof of their special adaptability to refinery service.

Advantages of Foster Wheeler Lowhead towers for petroleum refining use include:

**Full capacity in calm, hot weather.**
**More compact and efficient.**
**Less water loss.**
**Positive control over cooling range.**
**Low cost — low maintenance.**

FOSTER WHEELER CORPORATION
165 BROADWAY
NEW YORK, N.Y.

FOSTER WHEELER

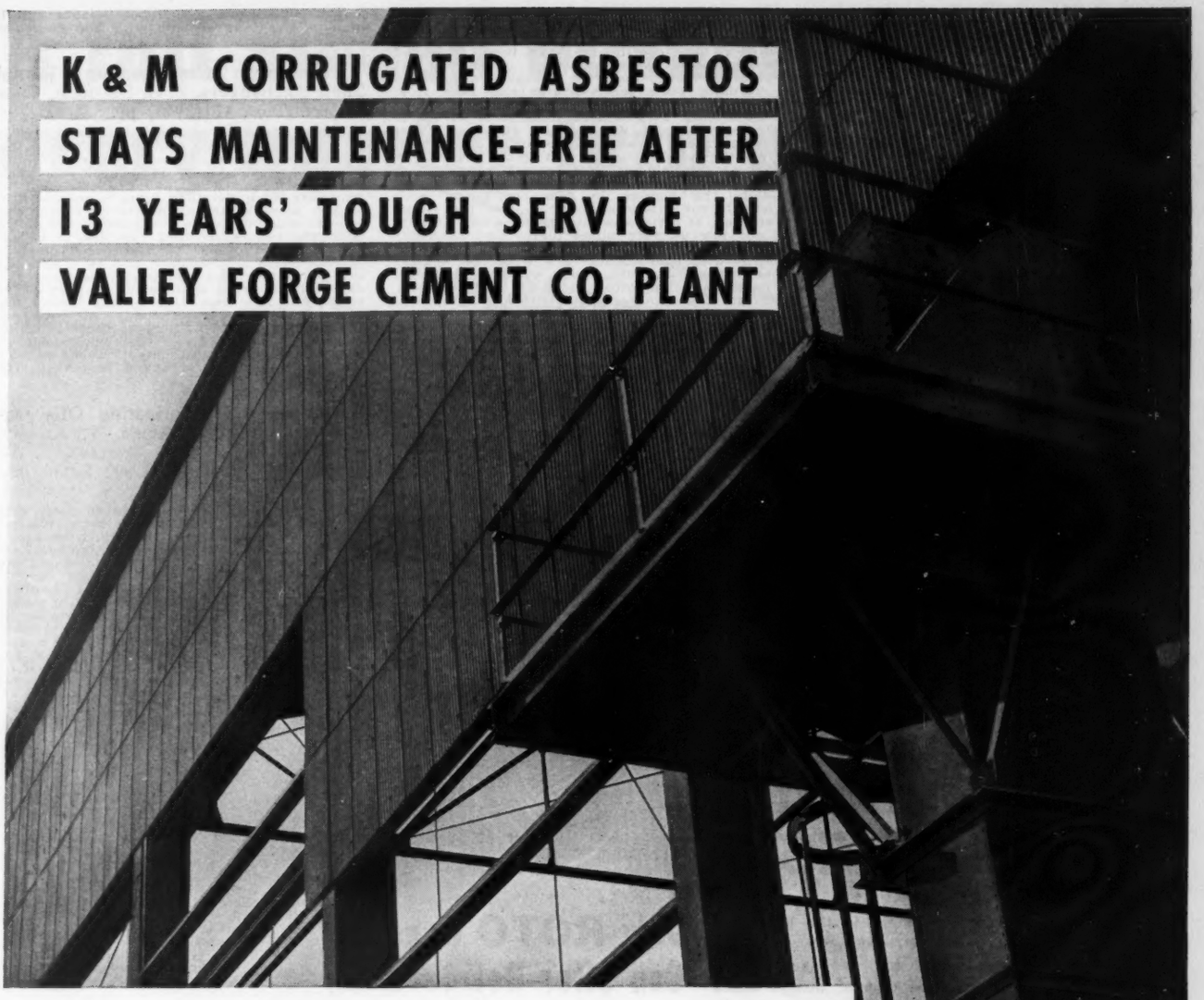

## Manufacture: Processes and Plant

**Multicomponent Rectification,** E. R. GILLILAND, *Ind. & Eng. Chem.* **32** (1940) pp. 1101-6.

For a given separation by rectification, the minimum number of theoretical plates required at total reflux and the minimum reflux ratio corresponding to an infinite number of plates are valuable aid to the designer because they define the limits within which his calculations must be confined to give an operable design. Satisfactory methods for the calculation of both these factors have been developed for binary mixtures. However, for the case of multicomponent solutions the problem is more complex, and only for the case of the minimum number of theoretical plates at total reflux have suitable methods been developed. In the present article, approximate equations are derived for the estimation of the minimum reflux ratio for multicomponent mixtures, and these equations can be used to calculate upper and lower limits for the true minimum reflux ratio. The use of the equations is illustrated by several examples, and it is shown that previous methods of estimating the true minimum reflux ratio can be greatly in error. Among the examples considered is that of gasoline stabilization.

**Condensation of Vapors on a Horizontal Tube,** E. M. BAKER AND U. TSAO, *Ind. & Eng. Chem.* **32** (1940) pp. 1115-21.

The extent of the use of steam distillation in the organic and petroleum industries indicates the importance of the problem investigated. The condensation of mixed vapors is almost a virgin field. Such limited work as has been done is reviewed by the authors. The apparatus used in the present investigation is described in some detail. A mechanical mechanism of the condensation of the vapors of non-miscible liquids was discovered. This overshadows many of the effects of the physical properties of the condensing liquids that influence heat transfer coefficients. From



# K & M CORRUGATED ASBESTOS STAYS MAINTENANCE-FREE AFTER 13 YEARS' TOUGH SERVICE IN VALLEY FORGE CEMENT CO. PLANT

● In the 13-year-old plant of the Valley Forge Cement Company, roof and sidewall maintenance have never had a chance to start. Maintenance expense was blocked from the beginning by the use of K & M "Century" Corrugated Asbestos on the sides and roofs of nearly all the buildings in the plant.

The conditions are tough, ranging from 100° inside temperatures in the kiln building to intense vibration in the crusher house, and the fumes of oleic acid and aluminum chloride in the froth-flotation building. In addition, the "Century" Corrugated has been exposed to cement and coal dust and 13 years of weather, all without needing a penny's worth of maintenance.

"If we'd known of a better product, either for dependability or economy, we'd have used it. We are so well pleased after this 13-year test of the products that we automatically renew our orders for them when new work requires it." —Valley Forge Cement Company.

You can depend on "Century" Corrugated to cut your building maintenance costs, too. Write Dept. 05 for complete catalogue information.

**K&M *"Century"* CORRUGATED ASBESTOS**

## KEASBEY & MATTISON

**COMPANY, AMBLER, PENNSYLVANIA**

a study of this mechanism a simple empirical equation was derived. This equation correlates not only the data for the vapor mixtures studied over extensive variations of vapor composition and temperature drop for two tube sizes, but also correlates the data of other workers. A wide range of vapor composition was studied for systems of water vapor mixed with vapors of benzene, toluene, chlorobenzene, trichloroethylene and tetrachloroethylene. At the eutectic temperature both of the non-miscible liquids will coexist with their vapors under equilibrium conditions. The eutectic temperature was used to calculate the temperature drops across the condensing film. Satisfactory correlations were obtained on this basis, but not on the basis of the actual vapor temperature less the temperature of the tube surface. Data secured in the work are presented in some detail in both tabular and graphical form, and the development of the correlating equation is given.

**Drop-Wise and Film Condensation of Steam,** F. L. SHEA, JR.,' AND N. W. KRASE, *Trans. Amer. Inst. of Chem. Engrs.* **36** (1940) pp. 463-90.

The literature of film and drop-wise condensation of steam is briefly reviewed. In the investigation reported both types of condensation were effected, using the same apparatus. Steam film coefficients, for both types of condensation were measured on a vertical plate 23 inches long. An improved method of obtaining plate temperatures and heat flow has permitted the measurement of drop-wise coefficients with a maximum error of about 20 percent and an average deviation from mean values of about 10 percent. Under film forming conditions the maximum error is 5 percent and the average deviation less than 2 percent. The Nusselt equation accurately predicts the change in film coefficient with length, for film condensation over the range studied. It gives absolute values about 10 percent low on very short plates and about 25 percent low when the length is 23 inches. Drop-wise coefficients vary with the lengths of condensers, with steam velocity and with heat load. The effect of heat load is small. From the range of velocities a graphical correlation, based on the frictional force exerted by the flowing steam on the condensate was developed. Interpretation of the data as dependent on length shows a substantially constant increase in resistance per foot of added length of condenser. This permits a prediction of average coefficients for longer condensers, which coefficients will be in substantial agreement with the data now available.

**Economy in Tube Grouping in Round-Shell Exchangers,** Z. G. DEUTSCH, *Chem. & Met. Engr.* **47** (1940) pp. 538-40.

There are many factors in the design of shell-and-tube heat exchangers other than calculation of the surface required. Some of these factors can be considered only on operating experience. Others, as the author points out, may be understood from a consideration of the possible arrangements of tubes. Four tube arrangements are discussed in the article, with the conclusion that two are to be preferred. Selection of the best arrangement is facilitated by a tabulation and by charts that are presented, and which can be used by a designer to avoid duplicating a part of the work that has been done by the author. One chart gives the relationship of exchanger shell diameter and number of tubes contained therein. Another gives the relationship of path areas inside and outside tubes to number of tubes when arranged in certain tube groupings.

**Synthesis of Lubricating Oils from Chlorinated Fatty Acids,** T. KUWATA, H. MATUBARA AND S. ASAHARA, *J. Soc. Chem. Ind., Japan* **43** (1940) Suppl. binding 80-2.

The decomposition of saturated fatty acids to form lubricating oils of high viscosity indexes is accomplished with greater ease if the fatty acids are first chlorinated, and acid clay is used as a catalyst. To avoid discoloration and oxidation, enough lime is added to remove the liberated hydrogen chloride. The greater the degree of chlorination of the fatty acids, the greater the specific gravity, refractive index, viscosity, molecular weight and iodine value of the oil. The best lubricant was secured when 1.5-2 atoms of chlorine were used per molecule of fatty acids. When lime was used, high-grade lubricants were obtained.

**Roofing Felts,** D. M. WILSON, *Petroleum* (London) **2** (1940) No. 1, pp. 15-22.

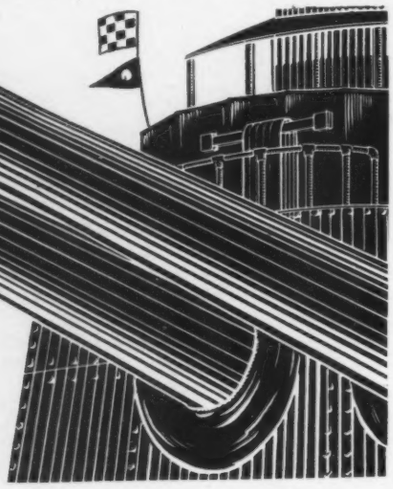
The history of roofing felts is briefly reviewed. Early products were coated papers. The development of tar paper that does not require coating treatment after application occurred chiefly in America. Many types of roofing felts are made today. Bituminous roofing felts comprise a saturated fiber base coated on one or both sides. The base is made on a paper-making machine from rags together with jute or Manila fibers. The weight of bitumen carried by 100 pounds of the felt base will vary from 100 to 180 pounds. The asphaltic bitumen used for saturation is usually of the straight-run type, having a penetration at 25° C. of 100 to 200. To seal voids that may remain after saturation it is usual to apply a coating of blown bitumen with a high melting point that will withstand high sun temperatures. Blown bitumens normally have a higher melting point for a given penetration than straight-run bitumens, and are more pliable over a range of temperature. The best blown stocks are made from a heavy asphaltic oil and the oxidation is conducted in such manner as to cause a minimum loss of light oils. One procedure is to blow the bitumen in a partly closed container under pressure of about 20-30 pounds per square inch. Curves are given that show the difference in melting point penetration relationship of bitumen blown under pressure and under ordinary pressure. A bitumen of high penetration index can also be made by fluxing a bitumen blown to a high melting point, such as 135° C. with some of the distillate produced in the blowing process, or with a suitable flux oil. A blown bitumen with high penetration index shows greater loss on heating than those with lower indexes.

**Petroleum Toluol for National Defense,** Editorial Staff *Chem. & Met. Engr.* **47** (1940) pp. 535-7.

In accordance with an announcement by E. R. Stettinius, member of the National Defense Advisory Commission in charge of raw materials, Government action is now being taken to stimulate increase in the production of toluol. Procurement of this TNT raw material is considered so important that steps are being undertaken by the Commission to assure added supplies, particularly from the petroleum industry. Editors of Chemical and Metallurgical Engineering have reviewed the literature on the subject for the purpose of comparing petroleum processes. The steps taken in the last war are reviewed, and other subjects covered are the pyrolysis of gases and synthetic processes for making toluene. Mention is made of the new Shell Petroleum Corporation plant at Houston, Texas, which is designed to produce 2 million gallons of toluene per year, and which can increase its production to 7 million gallons when necessary.

**Analysis of New Industrial Gas Ap-**


ROTO



*Rapid-Action*

**Guns Pay Big Dividends in REFINERIES**

**The success of modern equipment in the European war should impress every oil man with the need for an immediate study of his own equipment. Recent advances in Roto tube cleaner design make operation with old type guns highly unprofitable in refineries.**

**The 1940 rapid-action Roto Guns develop such speed and power that they reduce cleaning time in stills, cracking coils, boilers, etc., up to 30% and more. In some cases Roto Guns have saved enough in time, labor and compressor operation to pay for themselves in a single cleaning. Their exclusive time and labor saving features, listed here, will pay you handsome dividends for a long time. Let us prove it in your plant.**

**Only ROTO Guns Can Offer Refiners All These Features**

- ★ make full use of available air, without back pressure;
- ★ develop unbelievable speed and power, through new design;
- ★ air valve directly behind the motor permits one-man operation and eliminates signalling delays;
- ★ self-feeding cage and swing-frame heads, universal joints and drills have what it takes to do a real job;
- ★ available for straight and curved tubes ½" to 12" I.D.

***Model 112 Air-driven Motor with self-feeding cage-type head and air valve for one-man operation.***

*Write for Refinery Tube Cleaner Bulletin*

**The ROTO Company** 145 Sussex Ave. Newark, N. J.

# A full sweep of lubricant with every quarter turn of the plug

WALWORTH
LUBRICATED PLUG VALVES
have only 1 point of lubrication, but 4 points of lubricant feed
STICK LUBRICANT GOES HERE
THERE'S ONE BACK HERE
BACK HERE, TOO
HERE'S ONE POINT OF LUBRICANT FEED
HERE'S ANOTHER

At all times you are assured of easy operation . . . fast action . . . positive shut-off . . . greater protection against corrosion. Just a simple turn of the lubricant screw, at the top of the plug shank, forces the lubricant out through four holes, and down the channels into the chamber beneath the plug.

The valve is so designed that with every quarter turn (all that is necessary to open or close the port) lubricant from each of the four channels is wiped over the seating surfaces. The result is a *complete* sweep of sealing lubricant every time the valve is operated.

Get in touch with the Walworth jobber in your territory. He will be glad to acquaint you further with the advantages of Walworth Lubricated Plug Valves, or any other of Walworth's line of valves, fittings, pipes, and pipe wrenches. Do not hesitate to consult him.

**WALWORTH**

WALWORTH COMPANY
60 EAST 42nd STREET, NEW YORK

VALVES
FITTINGS
and TOOLS
Backed by
98 Years' Service

DISTRIBUTORS IN PRINCIPAL CITIES THROUGHOUT THE WORLD




More Dubbscracked Gasoline

**plications,** G. M. PARKER, *Gas Age* **86** (1940) No. 1, p. 20.

The non-luminous flame with which natural gas is burned in an ordinary manner radiates little, and in high-temperature furnace work dependence is placed on the radiation from hot brickwork. Natural gas, however, can be reformed to give a gas of lower Btu value, but which carries finely divided carbon particles that burn in a luminous manner. In applying gas reforming to the firing of an open-hearth furnace a small reforming chamber can be built in the air uptakes that usually bring hot air from the regenerators to the furnace. The reformed gas is injected into the furnace in a high-pressure jet of natural gas. This procedure results in reducing the fuel requirements of an open-hearth furnace 7 to 8 percent. If the furnace was designed for burning producer gas, part of the gas checker work can be used to reform the natural gas. By extensive reforming, if desired, natural gas can be changed to a gas of 150 Btu. heating value that has the burning characteristics of producer gas.

## Products: Properties And Utilization

**Mechanism of Boundary Lubrication Suggested by the Static Friction of Esters,** A. FOGG, *Proc. Phys. Soc.* (London) **52** (1940) pp. 239-45.

Steel surfaces at ordinary temperature were wetted with each of 10 ethyl esters in the series ethyl formate to ethyl stearate. The static coefficient of friction was measured in each instance. A maximum value of the coefficient of friction was obtained when using a compound of molecular weight of 120. This is in contrast to previously reported results on acids, alcohols and paraffins. If the assumption is made that the ester molecule attaches itself to the metal surface through the double-bonded oxygen, and that $R_1$ represents the acid and $R_2$ the alcohol radicals respectively, it is considered that the maximum coefficient of friction will be had with that ester in which the $R_1$ and O-$R_2$ are are equal in weight. Additional studies on methyl esters from methyl formate to methyl valerate confirm this assumption.

**(Automobile) Engine Deposits and the Effect of Some Fuel Additives,** J. H. MOLLER AND H. L. MOIR, *S.A.E. Journal* **46** (1940) pp. 250-61T.

For every set of engine conditions, the piston-head deposit reaches a state of dynamic equilibrium. Deposition and removal of deposits occur in waves or cycles. Mineral-oil or other similar fuel additives can have a marked effect on this equilibrium.

**Swelling of Synthetic Rubbers in Mineral Oils,** F. H. CARMAN, P. O. POWERS, AND H. A. ROBINSON, *Ind. & Eng. Chem.* **32** (1940) pp. 1069-72.

Several synthetic rubber compositions were subjected to long-time immersion tests in various mineral oils. The different oils had a markedly different swelling effect; in general, the logarithm of the percent volume change varied inversely with the cloud temperature of a 50 percent mixture of aniline and the oil. Previous work in other laboratories has indicated that the gravity index can be used as a criterion of swelling caused by lubricating oils. The aniline point is believed to be more reliable for mineral oils in general and is a more easily determined measure of swelling than the gravity index.

**A Preliminary Report on the Application of the Mass Spectrometer to Problems in the Petroleum Industry,** H. HOOVER, JR., AND H. WASHBURN, *Am. Inst. Mining Met. Engrs., Tech. Pub. No. 1205* (1940) 7 pp.

Individual components in a hydrocarbon gas can be determined with an accuracy of better than ±5% through use of a mass spectrometer which is described. Samples no larger than 0.1 cu. mm. at atmospheric pressure and room temperature can be analyzed. The mass spectrometer distinguishes between similar hydrocarbons, e.g., between butane and isobutane.

**A Large Spinning-Band Fractionating Column,** R. H. BAKER, C. BARKENBUS, AND C. A. ROSWELL, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 468-70.

The subject of laboratory fractionating columns is briefly reviewed, and it is noted that the one inherent weakness in all the columns mentioned is the relatively large liquid holdup. From a study of data on different types of columns it was concluded that the spinning-band type of column has the smallest holdup per theoretical plate. A 70-plate spinning-band column, having a holdup of 0.1 cc. per plate was constructed, and is described. The column is regarded as practical, is inexpensive, and can be used for analytical separations using small quantities of liquid.

**Kinematic Viscometer for Liquid Asphaltic Products,** A. P. ANDERSON, K. A. WRIGHT, AND R. L. GRIFFIN, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 466-8.

At present the Saybolt Furol viscometer is used to determine the viscosities of asphaltic liquid road materials. However, the results are expressed in empirical rather than absolute units, and it is necessary to use a number of temperatures in order to cover the desired viscosity range. A new type of kinematic viscometer has been developed for measuring viscosities in centistokes of the whole range of commercial asphaltic liquid road materials at a single temperature. This incorporates features in design to facilitate the operations of filling, adjustment of hydrostatic head, and cleaning. Three capillaries of decreasing bore diameters arranged in series with intervening bulbs permit measurements of viscosities over an extended range without changing capillaries or pressures, as is necessary in other types of instruments. The instrument is described in some detail, the method of operation is given, and a comparison of data for different types of viscometers.

**Accurate Timing Equipment for Viscosity Determinations,** E. M. FRY, JR., AND E. L. BALDESCHWIELER, *Ind. & Eng. Chem.,* Anal. Ed. **12** (1940) pp. 472-3.

The determination of viscosities requires close control of both time and temperatures. The timing problem has been particularly difficult to solve, since one is concerned not only with absolute time, but also with being able to reproduce short-time intervals with a high degree of accuracy. A method and an apparatus for obtaining accurate timing for short intervals are described. The accuracy is better than ± 0.1 percent of intervals of 100 seconds or over.

MODERN FURNACE LINING:
TILE
High grade refractory tile, accurately made by the dry press process, with the Detred tongue and groove on all four sides provides maximum air tightness and presents a smooth surface which will not spall or crumble.
+ HANGER
The shape of the tile, hangers, and supporting members are designed to hold each tile individually, and support the wall in sections in such a way as to take up the shocks of expansion and contraction under changes in temperature.
+ INSULATION
Detrick Block Insulation is applied to the Thinsulite wall and the joints filled with bonding cement to produce an air-tight and heat-tight covering. The result is a light 6-inch wall with less heat loss than that of a conventional 18-inch solid construction.
+ DETRICK ENGINEERING
Added to these three physical elements is the training and experience of Detrick Engineers — leaders in furnace design for more than a quarter century. You will find it economical to apply all four factors to your next oil heater or boiler job.
Be sure to see the new Thinsulite booklet showing heat transfer curves and other data.
Thinsulite WALLS and ARCHES
M. H. DETRICK COMPANY
140 S. DEARBORN ST. CHICAGO, ILLINOIS

# *More Dubbscracked Gasoline*

Today ten more refiners are making Dubbscracked gasoline in United States and Canada than were making it a year ago—or are building Dubbs units—adding more than 16,500 barrels a day to rated Dubbscracking capacity

That's lucky for those refiners, it's lucky for the marketers who sell their gasoline—it's lucky for the motorists who buy it

Last September, 62 American and Canadian refiners were producing Dubbscracked gasoline or getting ready to Today there are 72, and here they are:

| | |
|---|---|
| Arro Oil & Refining Co | *Lewistown, Mont* |
| Ashland Oil & Refining Co | *Ashland, Ky* |
| Aurora Gasoline Co | *Detroit, Mich* |
| Bareco Oil Co | *Wichita, Kansas*<br>*Corpus Christi, Texas* |
| Bay Petroleum Corp | *McPherson, Kansas*<br>*Denver, Colorado* |
| Bell Oil & Gas Co | *Grandfield, Okla* |
| Ben Franklin Refining Co | *Ardmore, Okla* |
| Berry, James B Sons Company | *Oil City, Pa* |
| Big West Oil Co | *Kevin, Mont* |
| Black Gold Refining Co | *Oklahoma City, Okla* |
| Canton Refining Co | *Canton, Ohio* |
| Continental Oil Co | *Ponca City, Okla* |
| Continental Refining Company | *Oil City, Pa* |
| Cooperative Refinery Association | *Phillipsburg, Kansas* |
| Cosco Oil Co | *Wynnewood, Okla* |
| Cosden Oil Corp | *Big Spring, Texas* |
| Cushing Refining & Gasoline Co | *Cushing, Okla* |
| Danciger Oil & Refineries Inc | *Longview, Texas*<br>*Pampa, Texas* |
| Deep Rock Oil Corp | *Cushing, Okla* |
| Derby Oil Company | *Wichita, Kansas* |
| Eagle Oil & Refining Co | *Santa Fe Springs, Cal* |
| Elk Refining Co | *Falling Rock, W Va* |
| El Tejon Oil & Refining Corp | *Bakersfield, Cal* |
| Empire Oil & Refining Co | *Ponca City, Okla* |
| Fletcher Oil Co Inc | *Los Angeles, Cal* |
| Freedom Oil Works Co | *Freedom, Pa* |
| Glacier Production Co | *Cut Bank, Mont* |
| Gramps Oil & Refining Corp (L M Hughes) | *Alamosa, Colorado* |
| Home Oil & Refining Co | *Great Falls, Mont* |
| Independent Refining Co | *Laurel, Mont* |
| Independent Refining Co | *Arp, Tex* |
| Inland Empire Refineries Inc | *Spokane, Wash* |
| Johnson Oil Refining Co | *Cleveland, Okla* |
| Kendall Refining Co | *Bradford, Pa* |
| Leonard Refineries Inc | *Alma, Mich*<br>*St Louis, Mich* |
| Louisville Refining Co | *Louisville, Ky* |
| Malco Refineries, Inc | *Artesia, New Mexico* |
| McMurrey Petroleum Corp | *Tyler, Texas* |
| Mid-West Refineries, Inc | *Alma, Mich* |
| Mohawk Petroleum Corp | *Mopeco, Kern Co, Cal* |
| Naph Sol Refining Co | *Muskegon, Mich* |
| National Refining Co | *Coffeyville, Kansas*<br>*Findlay, Ohio* |
| Northwest Refining Co | *Cut Bank, Montana* |
| Pana Refining Co | *Pana, Ill* |
| Panhandle Refining Co | *Lueders, Texas*<br>*Wichita Falls, Texas* |
| Pennzoil Co | *Oil City, Pa* |
| Phillips Petroleum Company | *Kansas City, Kansas*<br>*Okmulgee, Okla* |
| Quaker State Oil Refining Corp | *Farmers Valley, Pa*<br>*Emlenton, Pa*<br>*St Marys, W Va* |
| Root Petroleum Company | *El Dorado, Arkansas* |
| Rothschild Oil Co | *Santa Fe Springs, Cal* |
| Shamrock Oil & Gas Corp | *Moore County, Texas* |
| Shell Oil Co Inc | *Dominguez, Calif*<br>*East Chicago, Ind*<br>*Houston, Texas*<br>*Martinez, Calif*<br>*Sellers, La*<br>*Wilmington, Calif*<br>*Wood River, Ill* |
| Socal Oil & Refining Co | *Huntington Beach, Cal* |
| Socony-Vacuum Oil Co, Inc (White Star Division) | *Trenton, Mich* |
| Standard Oil Co of California | *El Segundo, Calif*<br>*Richmond, Calif* |
| Sunray Oil Co | *Allen, Okla* |
| Talco Asphalt & Refining Co | *Mount Pleasant, Texas* |
| United Refining Co | *Warren, Pennsylvania* |
| Valley Refining Co | *Roswell, New Mexico* |
| Vickers Petroleum Co | *Potwin, Kans* |
| Waggoner Refining Co, Inc | *Electra, Texas* |
| Wilcox, H F Oil & Gas Co | *Bristow, Okla* |
| Wilshire Oil Co, Inc | *Santa Fe Springs, Cal* |
| Wolverine-Empire Refining Co | *Reno, Pennsylvania* |

**CANADA**

| | |
|---|---|
| Anglo-Canadian Oils, Ltd, *Brandon, Manitoba* | Good Rich Refining Co, *Port Credit, Ontario* |
| British American Oil Refineries, Ltd, *Toronto, Ontario* | Lion Refining Co, *Calgary, Alberta* |
| Canadian Oil Companies, Ltd, *Petrolia, Ont* | North Star Oils, Ltd, *St Boniface, Man* |
| Consumers Cooperative Refineries, Ltd, *Regina, Sask* | Shell Oil Company of Canada, Ltd, *Montreal, Quebec* |

Is your name written there? It ought to be

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor

# New Equipment for the Modern Plant

## Regulator

**PITTSBURGH EQUITABLE METER COMPANY**

A regulator of high-pressure-balanced-valve design fitted with a standard pilot loading head and an orifice plate set at the outlet of the main regulator to provide automatic loading has been announced by Pittsburgh Equitable Meter Company, Pittsburgh.

**Emco Automatic Loading Regulator**

As the flow rate increases through the regulator, the pressure differential increases across the orifice plate with the square of the velocity. The differential pressure is led by means of piping to a differential diaphragm head. The diaphragm head has mounted on it a pilot loading regulator, so connected to the differential boosting head that as the differential pressure across the head increases, the pilot loading regulator diaphragm is more heavily loaded. This has the same effect as increasing the control spring loading. With increasing flow rate, the orifice differential increases, which in turn increases the loading on the differential boosting head. This results in an increased loading of the base pressure pilot regulator and raises the outlet pressure. To provide a maximum limit as a safety or a point beyond which the regulator can not boost the pressure, a pilot loading regulator is set in series ahead of the pilot loading regulator.

Separate assemblies are used to make up the component parts in this system of loading to make it possible to adapt the loading system to existing regulators and to regulators now equipped with pilot loading heads. The actual arrangement of the parts can be varied so as to provide the most accessible and convenient installation or to conform with the dimensions of any vault or regulator house.

## Water Detector

**WATERTECTER COMPANY**

A chemical paste which, when spread in a thin layer upon a gauge stick, indicates the water level in a tank of gasoline, crude or fuel oil, has been announced by Watertecter, 1816 Statler Hotel Building, Buffalo, New York.

Pink in color and marketed in a tube container, the paste turns to white 10 seconds after immersion in water. It retains its original pink color above the water line.

## Reversible Wrenches

**CHICAGO PNEUMATIC TOOL COMPANY**

Three new reversible wrenches, with bolt size capacity of ⅜-, ⅝-, and ¾-inch, respectively, have been announced by Chicago Pneumatic Tool Company, 6 East 44 Street, New York.

They employ slow speed rotary motors, have no gears, use a springless

**Chicago Pneumatic's Reversible Wrench**

driving unit, and have short overall lengths and tapered nose ends. Each model has an 8-foot 5/16-inch air hose and fittings as standard equipment.

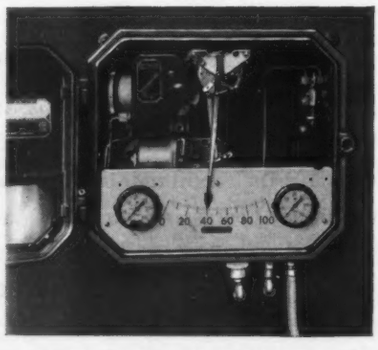
Model CP 344-R, of ⅜-inch bolt size, is 6½ inches overall; has spindle offset of 1⅜ inches, ⅜-inch square shank, and weighs 4¼ pounds. Model CP 349-R, of ⅝-inch bolt size, is 9¾ inches overall; has spindle offset of 1⅝ inches, ½-inch square shank, and weighs 9½ pounds. Model CP 360-R, of ¾-inch bolt size, is 10 inches overall; has spindle offset of 1¾ inches, a ¾-inch square shank, and weighs 13 pounds.

## Remote Indicating System

**TAYLOR INSTRUMENT COMPANIES**

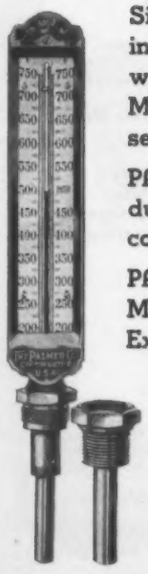
A new pneumatic system for correlating temperature, pressure, flow or liquid-level data on a centralized panel or in a control room, designated Taylor remote pneumatic transmission system, has been announced by Taylor Instrument Companies, Rochester, New York.

Utilizing standard Taylor instruments, the system may consist of one or two transmitters connected to a receiver, or one or more receiving instruments, not necessarily near each other, and as far as



**Taylor Indicating Transmitter**


**THE WATCH DOGS IN YOUR PLANT!**



**Silent watch dogs that never fail to indicate correct temperatures. Trustworthy . . . reliable . . . dependable. Made correctly to give many years of service.**

**PALMER "Red-Reading-Mercury" Industrial Thermometers, with wide RED column, plain to see anywhere.**

**PALMER "Superior" Dial Thermometer, Mercury-Actuated . . . Sturdy built . . . Extremely accurate.**

***(Write for new catalog No. 200-F)***

**See detailed data, page 261, 1940 Refinery Catalog**

**THE PALMER CO.**

***Manufacturers: Industrial, Laboratory, Dial and Recording Thermometers***

**2513 NORWOOD AVE., CINCINNATI NORWOOD, OHIO**

**King & George Sts., Toronto, Canada**

# THE RIGHT VALVE IN THE RIGHT PLACE

It is just about an axiom of refinery operation that fitting the valve to the service pays well — not only in reduced valve replacement and maintenance costs, but also in the avoidance of expensive and troublesome interruptions to service.

In cases where operating temperatures run up to 1200° F. and there is a likelihood of corrosion, Chromium-Molybdenum (high Chromium) steel is proving to be the valve material that "fits the service".

This steel has excellent resistance to creep and retains its strength and toughness at operating temperatures. Furthermore, its resistance to the corrosive action of hot petroleum liquors has a marked effect on valve life.

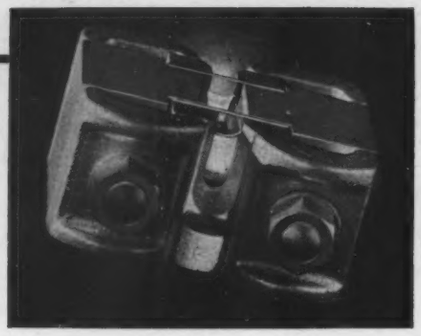
Complete data on Chromium-Molybdenum and other heat-resisting Molybdenum steels for refinery use are contained in Section 8 of our technical book, "Molybdenum in Steel". Either the complete book or the individual section will be sent free on request to interested executives or engineers.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

**Climax Mo-lyb-den-um Company**
**500 Fifth Avenue, New York City**

MOLY

**You're Money Ahead with MICASIGHT SAFETY GAGES**



*Remove the Danger of Flying Glass*

**Your tanks and vessels need this temperature-defying MICASIGHT to make safe the important job of watching liquid levels. You're money ahead when you remove danger of flying glass—avoid loss of liquid and possible fire hazard.**

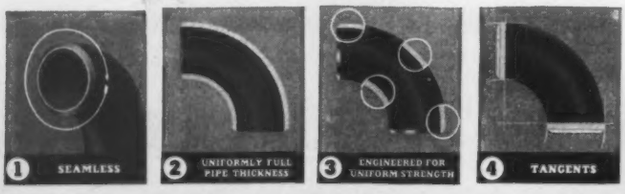
**Leakproof Micasight Inserts install quickly in your present gage valves or in long-lasting Reliance Forged Steel Valves. Can be illuminated for bright sharp reading. Install this praise-winning safety gage as hundreds of progressive engineers have done . . . Write today for MICASIGHT Bulletin.**

**THE RELIANCE GAUGE COLUMN CO.**

**5902 Carnegie Avenue, Cleveland, Ohio**

**Reliance**






**TAYLOR FORGE**

**EACH one of these features guards against trouble and delay on the job. You'll find them combined only in WeldELLS**

**Seamless Pipe Fittings** **WeldELLS** **For Faster Easier Welding**

TAYLOR FORGE & PIPE WORKS: General Offices and Works: Chicago, P. O. Box 485
New York Office: 50 Church St. Philadelphia Office: Broad Street Station Bldg.

1000 feet from the transmitter. Transmitters or receivers may be indicating, recording or controlling types. Quarter-inch copper tubing is the means of connection for the air transmitting medium.

The system is described as accurate within 1 percent of the scale range when properly installed, and speed of response of the receiver to changes in output air pressure from the transmitter is largely dependent upon distance, maximum lag said to be 1 second per 100 feet of connecting tubing.

The system is designed to do away with electrical circuits in explosive atmospheres, and to measure, transmit and receive continuously regardless of electrical current failures. The operator out on the unit is provided with an indicating or recording instrument for observation, eliminating the necessity of returning to the main control board to check performance of the unit.

## Adjustable Wrench

**BONNEY FORGE & TOOL WORKS**

A line of open-end adjustable wrenches in 4-, 6-, 8-, 10- and 12-inch lengths with capacities ½ to 1-7/16 inches has been announced by Bonney Forge & Tool Works, Allentown, Pennsylvania.

**Bonney Adjustable Wrench**

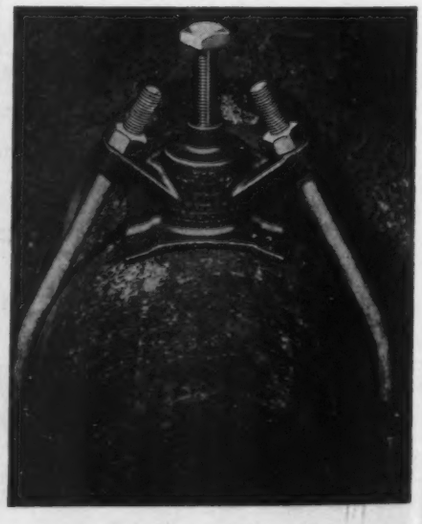
Drop forged of alloy steel, with handle and jaw hardened and tempered in oil, they are designed with four tempered threads meshing in the forged jaw to permit pressure on the handle and to preclude breaks or wear in the gear teeth. Jaws are designed to fit square or hexagon nuts. The wrenches are chrome plated with polished jaws.

## Vented Plug Clamp

**M. B. SKINNER COMPANY**

A plug clamp for high-pressure pipe lines designed so that the pressure vents while the clamp is being placed in position, followed by closing of the plug, has been announced by M. B. Skinner Company, South Bend, Indiana.

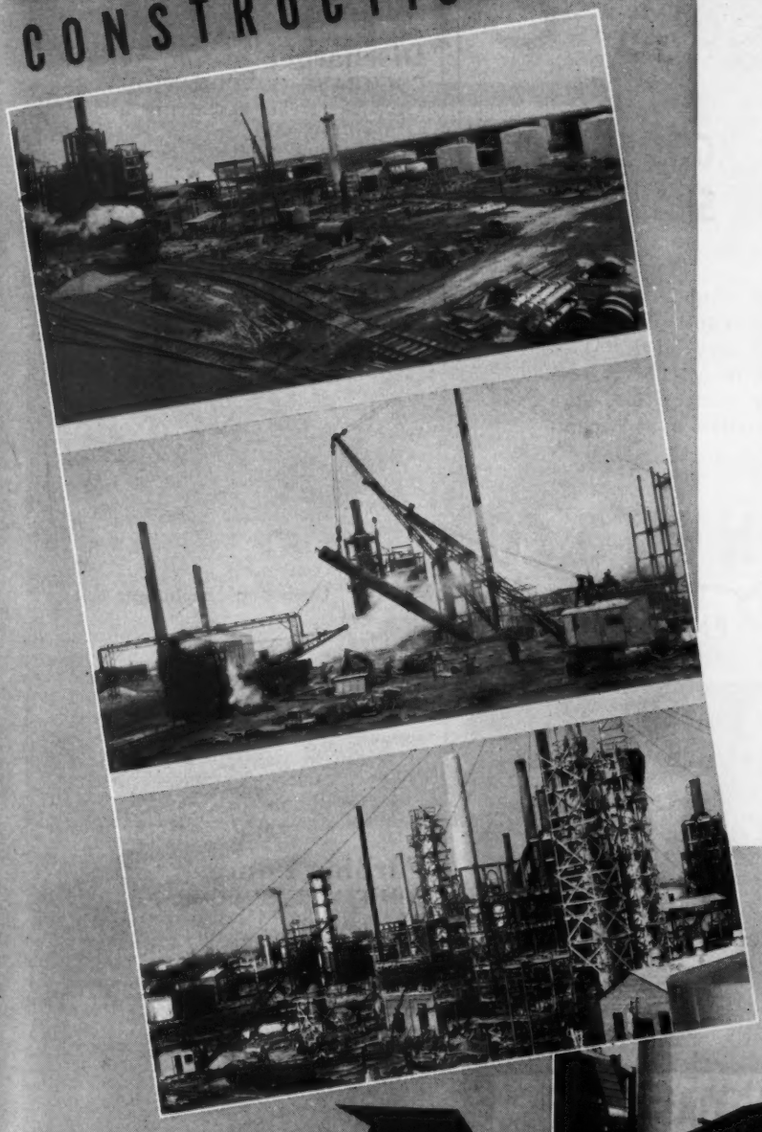
The head of the clamp consists of a malleable iron cylinder resting on a pressure-distributing base, anchored to the pipe



**Skinner's Vented Plug Clamp**

# GRAVER'S
## CONSTRUCTION DIVISION

*a complete*
**CONSTRUCTION ORGANIZATION**
**FOR THE PETROLEUM INDUSTRY**



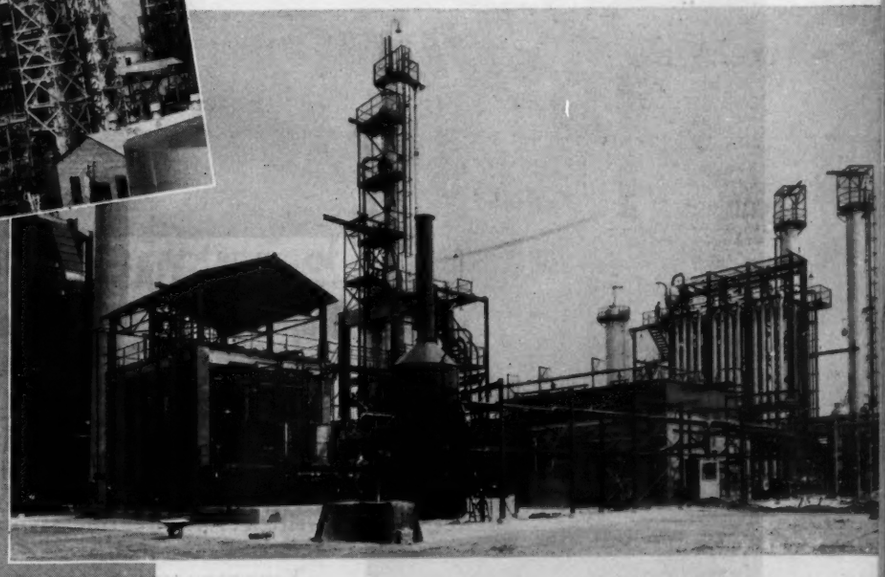
INDIVIDUAL requirements of refineries, large and small, have been thoroughly anticipated in the organization of Graver's Construction Division—formed to effect economical and competent erection of equipment and other facilities for the Petroleum Industry.

Although no engineering or designing is included in the activities of this division, it is fully equipped with all of the tools, erecting equipment, and personnel to assure efficient handling of any construction project, regardless of size. These facilities, combined with Graver's complete access to skilled labor in all areas, mean that each Graver client can count on speedy erection and "on time" completion.

You may need to erect just one processing unit, or perhaps, a small pipe job, and then again, you may want a complete refinery. But whatever you do require you'll find that Graver's Construction Division can do the job—and do it right!

Why not ask for complete details? Just address Graver Tank & Mfg. Co., Inc., 332 S. Michigan Ave., Chicago, or 424 Madison Ave., New York City.

•GRAVER IS NOT MARKETING ANY PATENTED PROCESS PARTICULAR TO THE OIL REFINING INDUSTRY, AND MANUFACTURES NO SPECIAL PATENTED PROCESS EQUIPMENT.



ABOVE: Three pictures showing progressive stages in the erection of equipment by Graver at the refinery of a major oil company.

RIGHT: View shows completed erection of same equipment.

# GRAVER TANK & MFG. CO., INC.

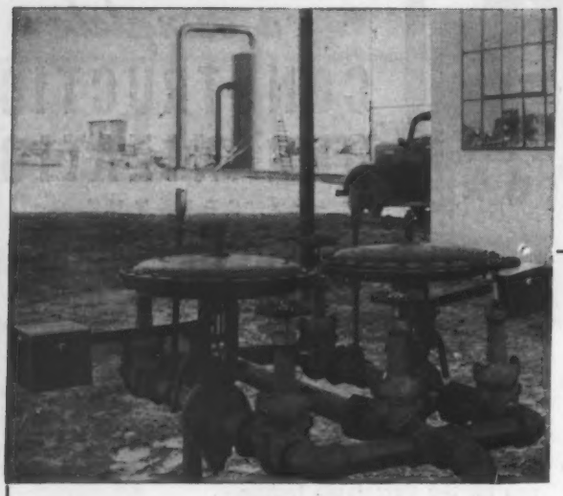
*OVER THREE QUARTERS OF A CENTURY OF DEPENDABLE SERVICE*

NEW YORK
CATASAUQUA, PA.

EAST CHICAGO, IND.

CHICAGO
TULSA

CABLE ADDRESS—GRATANK



*Two C-F Low-Pressure Regulators with Automatic Cut-Off on a Texas gas line.*

**IF GAS SUPPLY SHOULD FAIL**

THE two C-F Low-Pressure Regulators with Automatic Cut-Off here seen, are on a gas line of a Texas refinery owned by one of the great oil-producing companies. Like all C-F low-pressure Regulators, they afford protection in case of failure of gas supply. Their merits include sturdy construction, sure precision, and long life as well as easy installation and maintenance. Write for new Catalog.

**The CHAPLIN-FULTON MFG. CO.**

28-40 PENN AVE. CF PITTSBURGH, PA.

**New GASKET Handbook and Catalog**

64 fact-packed pages of advanced engineering data . . . complete size and price information . . . many new and improved products . . . profusely illustrated . . . concisely written . . . to offer time-saving reference.

*Your copy sent on request.*

**GOETZE GASKET & PACKING CO., Inc.**
8 Allen Avenue, New Brunswick, N. J.
*Branch Offices in Principal Cities*
"America's Oldest and Largest Industrial Gasket Manufacturer"

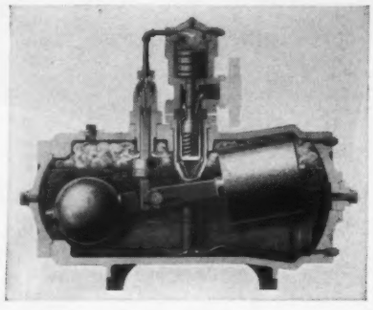

by bolts and straps. The cylinder is fitted with a rubber-faced metal piston operated by a heavy thrust-screw gasket surface 2-3/16-inch in diameter.

The lower rim of the gasket is armored with a brass band to prevent burning in the last stages of shutting off and to prevent rubber from escaping through the vent. The bottom of the gasket is ground to fit curvature of pipe, and the piston is keyed in the cylinder to prevent rotating out of position while thrust screw is being tightened.

## Discharger

**COCHRANE CORPORATION**

A discharger, essentially a positive-acting trap designed to handle large quantities of condensate or carryover at relatively high pressures, has been announced by Cochrane Corporation, 17 Street and Allegheny Avenue, Philadelphia.



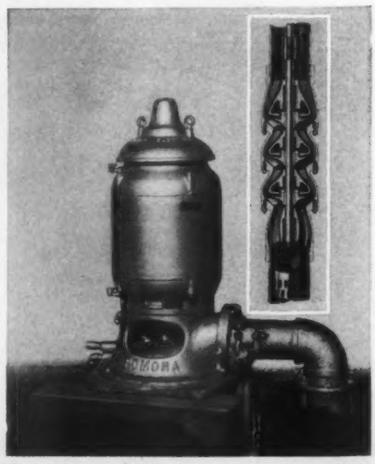
**Cochrane Discharger**

The device, by means of a pilot valve, applies steam line pressure to open the discharge valve. Displacement weights of different densities move the pilot control valve. When the pilot valve has opened, steam is admitted to the top of the main valve piston, opening the discharge valve. Drains are discharged from the bottom of the body through the eduction pipe to the outlet.

## Turbine Pumps

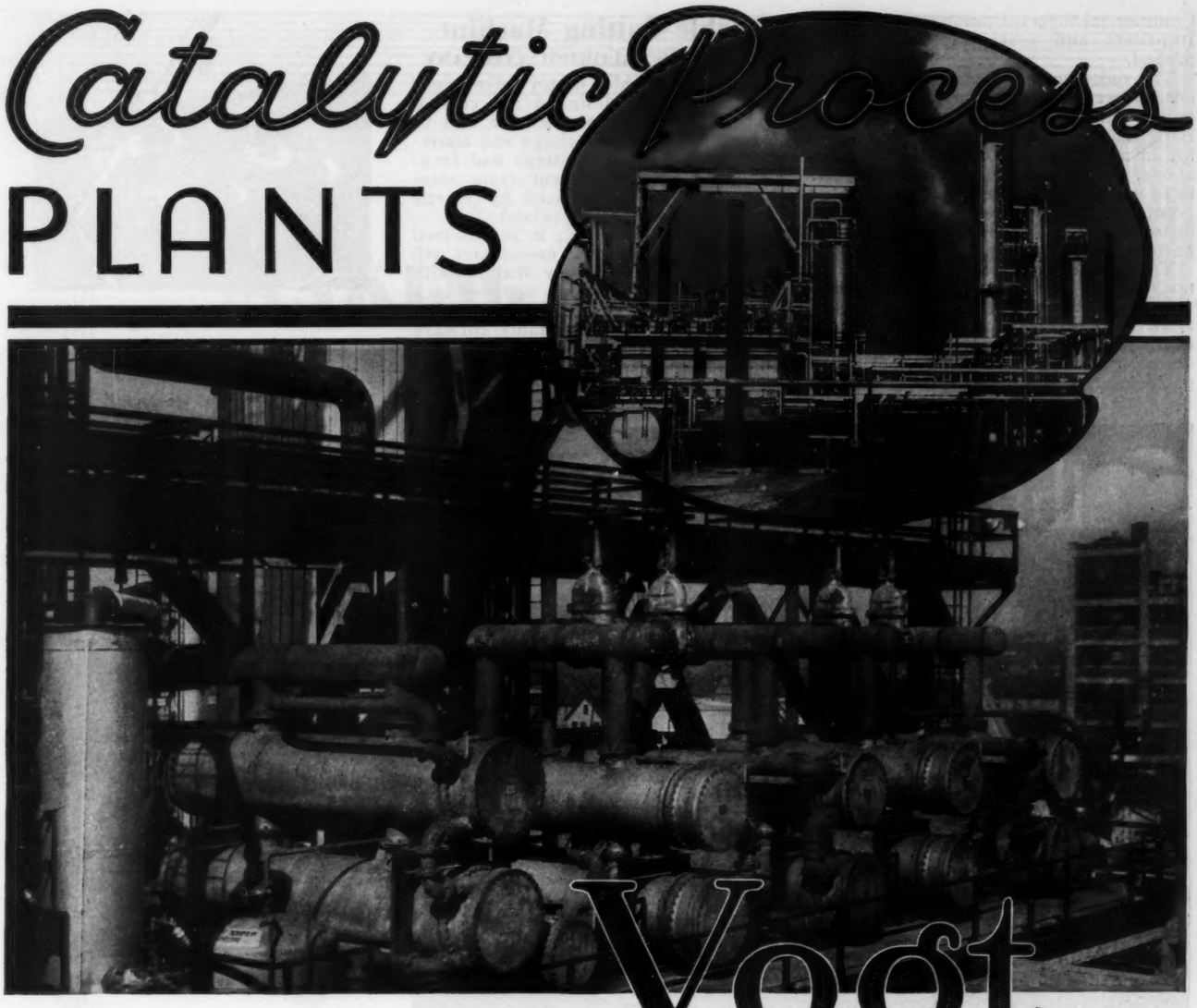
**POMONA PUMP COMPANY**

Redesign of its line of 6-inch medium-capacity vertical turbine pumps to obtain higher efficiency and better performance has been announced by Pomona Pump Company, 611 East



**Pomona's redesigned vertical turbine pump. Insert shows cross section view of pumping stages with newly designed impellers and seats.**

# Catalytic Process PLANTS



# Vogt and VAPOR CONDENSERS

**VOGT PRODUCTS for the Refinery**

HEAT EXCHANGERS
DROP FORGED STEEL VALVES, FITTINGS AND FLANGES • OIL REFINERY EQUIPMENT
REFRIGERATION EQUIPMENT • WATER TUBE BOILERS

**The acceptance of Vogt heat transfer equipment for advanced engineering design and continuous, trouble-free service is evidenced by its selection for outstanding catalytic process plants now operating and under construction.**

**HENRY VOGT MACHINE CO., INC.**
LOUISVILLE, KENTUCKY

NEW YORK • PHILADELPHIA • CLEVELAND • CHICAGO • CINCINNATI • ST. LOUIS • DALLAS

Commercial Street, Pomona, California. Impellers and seats have been improved.

The redesigned pump requires a 7½-horsepower motor, against a 10-horsepower unit for the old model, to pump 100 gallons per minute against 110-foot lift in a well with 50 pounds pressure above. Efficiency of the pump for this head capacity has been increased 6½ points, number of stages has been reduced one fourth, and initial cost has been lowered 20 percent.

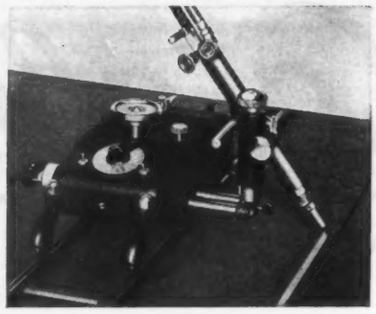
The pumps are water-lubricated, with no stuffing box below ground level; the semi-open impeller can be adjusted from the surface for wear and for changing capacity, and the pumps are described as non-sandlocking and non-gaslocking.

## Portable Cutting Machine

**THE HARRIS CALORIFIC COMPANY**

A new portable motor-driven gas cutting machine, designed for cutting steel of light or heavy section and to enable metal working shops and manufacturers to replace castings and forgings with parts flame-cut from steel plate, has been announced by Harris Calorific Company, Cleveland.

Designated Model K, it is powered by a Universal electric motor and will cut straight lines of any length, with square or beveled edges; 1- to 86-inch diameter circles; and has a speed range from 3 to 60 inches per minute, forward or reverse. An instant stop feature permits cutting sharp angles, and a tracing feature provides for cutting irregular forms. Instant reversing is provided by a switch.



**Harris Calorific Cutting Machine**

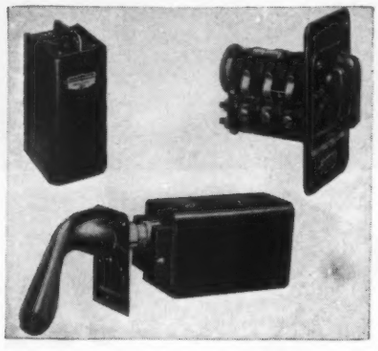
The unit, which weighs 45 pounds, obtains traction through two hardened drive wheels. Swivel follower wheels provide 4-point support, and an oiling feeder line provides lubrication to all bearings.

Torches to use acetylene, propane, natural gas and other fuel gases in combination with oxygen are available for use with the machine. Standard equipment includes cutting torch and tip, torch mounting, circular cutting attachment, 5-foot track, and electric socket plug.

## Drum Type Switch

**CUTLER-HAMMER, INC.**

A drum type master switch providing 3-wire control for machine tools and other equipment has been announced by Cutler-Hammer, Inc., Milwaukee.



**Cutler-Hammer Drum Type Switch**

The switch is designed to afford functions equivalent to two- and three-button heavy duty push button stations, and is offered for use where operating lever is preferred. Three kinds of construction are available, surface, cavity and panel mounting, and two kinds of handles, standard and pistol grip. By removing a stop post, the drum may be converted from non-reversing to reversing.

## Volt-Ammeter

**GENERAL ELECTRIC COMPANY**

A portable hook-on volt-ammeter for measuring alternating current and voltage has been introduced by General Electric Company, Schenectady, New York. It is designed for instantaneous reading of alternating current on both insulated and non-insulated conductors by hooking the instrument around the line. For voltage readings, it is necessary to connect two leads furnished with the instrument and then flip a


LIGHTWEIGHT LINING

GIVES HIGH INSULATION IN PORTABLE PIPE STILLS!

**LUMNITE** *linings help make portable stills really portable!*

**The Problem:** What lining for a portable pipe still has satisfactory refractory properties . . . provides high insulation . . . and yet *is light in weight?*

**The Solution:** The R. B. Millard Engineering Company, in California, found the answer in Refractory Concrete made of LUMNITE and insulating aggregates. With this monolithic lining, they got the insulation needed to cut heat loss and protect the shell, at the same time reducing the total weight of the still. Elimination of joints and close contact with the steel means greater protection.

Other manufacturers of such equipment are also taking advantage of the light weight of Refractory *Insulating* Concrete made with LUMNITE. Cast in place to fit the job, the linings are simple to install even in small diameter shells and against irregular surfaces.

Because of its adaptability, low first cost and easy maintenance, refinery operators and builders turn to LUMNITE for protection against heat and corrosion. For detailed information, write for "Oil Refinery Manual." Atlas LUMNITE Cement Company (United States Steel Corp. Subsidiary), Dept. R-5, Chrysler Bldg., New York City.

LUMNITE FOR REFRACTORY CONCRETE

# MAKING ASSURANCE DOUBLY SURE...

THE USE of the Furfural Refining Process, or the Solvent Dewaxing Process is the *first* assurance of high operating efficiency at low operating cost—but that is not all.

To assure the latest technical improvements—and greatest efficiency of plant operation, the Texaco Development Corporation supplies all technical information for the design of the licensee's plant.

After the plant has been constructed by an accredited construction company, the Texaco Development Corporation cooperates in putting it into quick operation by making available its own highly trained personnel to start the plant, and to train the licensee's men to operate it efficiently in the shortest possible time.

In all cases the licensee, with its own personnel, makes the acceptance test of the completed unit.

TEXACO
REG. T. M.

**TEXACO DEVELOPMENT CORPORATION**

A Subsidiary of The Texas Corporation

26 Journal Square • Jersey City, N. J.

thumb-manipulated selector switch to the desired voltage position on the scale.

It is designed for use on conductors of 2-inch maximum diameter, small enough to get into tight places, and light enough to be hung from a lineman's belt. Four current ranges, 0-15/60/150/600 amperes, and two voltage ranges, 0-150/600 volts, are available at setting of a 6-position snap switch.

The transformer, indicating instrument, internal resistors for extending the range, and selector switch are all mounted in a textolite case. The handle, molded as part of the case, is designed to provide insulation and safety for the operator. A slot for a carrying strap is molded in the handle.

## Alloy

**COLONIAL ALLOYS COMPANY**

Addition of Colalloy No. 301 to its line of light alloys has been announced by Colonial Alloys Company, East Somerset and Trenton Avenue, Philadelphia.

The material, on the basis of a Tinius Olsen test, showed ultimate tensile strength of 72,110 pounds per square inch, 32 percent elongation in 2 inches, 57,530 pounds per square inch yield point, 16.5 percent reduction of area in original section, and 109 Brinell.

It is described as lending itself to gas welding, spot welding, seam welding, arc welding, brazing, soldering, chemical fusion welding and reaction soldering; as non-magnetic and non-sparking, and as approximately 66 percent lighter than steel or iron and 70 percent lighter than brass, copper, nickel, bronze or their alloys.

## Air-Cooled Transformer

**WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY**

Air-cooled transformers of advanced design to provide a higher factor of operating safety, designated Type ASL, have been announced by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

Designed for installation in buildings where safety is essential, the units have 60-cycle ratings ranging from 150- to 500-Kva inclusive for single-phase and 150- to 1000-Kva inclusive for 3-phase, voltages 13,200 and below.

The housing is constructed of expanded metal finished in a black baked-on moisture-proof enamel to permit a free and easy flow of air from all sides and to provide safety against accidental contact with live terminals. The primary and secondary coils are separated by spaces through which a stream of air circulates. Windings are designed for a 75° C. temperature rise under continuous full-load operation.

Heat-resisting insulation, including porcelain, asbestos, mica, glass and air, are used throughout.

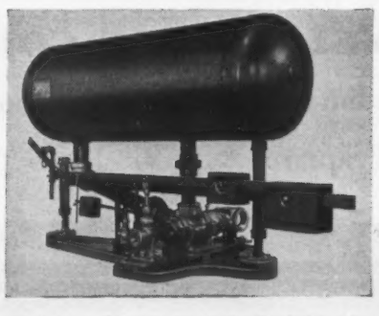
## Boiler Feeder

**W. M. ACKER ORGANIZATION, INC.**

An automatic system for steam drainage and boiler feeding, designed to deaerate water fed to boilers, liberating oxygen and non-condensable gases detrimental to metal under heat and pressure, has been announced by W. M. Acker Organization, Inc., 3167 Fulton Road, Cleveland.

The design of the equalizer emphasizes new features in the rocker section which bears the brunt of mechanical operation. The naval bronze female trunnion receives direct support from a bearing unit composed of two split bearings cast integral to insure permanent alignment and located in the center of the rocker section, carrying the full load of the tilting mechanism. No weight rests on the packing.

Male steam end and water end are bolted independently to a heavy bridged base to hold all elements in rigid alignment. Other features include stuffing boxes with split packing glands held by T-head bolts; Alemite fittings for lubricating bearings and packing, A. S. M. E.-certified heavy galvanized steel tank, dirt-proof bumers, and union tank connections.

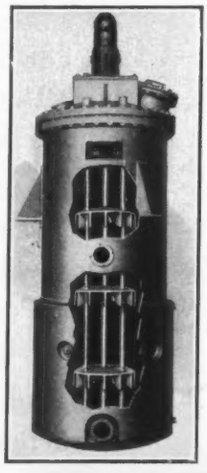


**Acker Organization's Equalizer**

## Gas Absorber

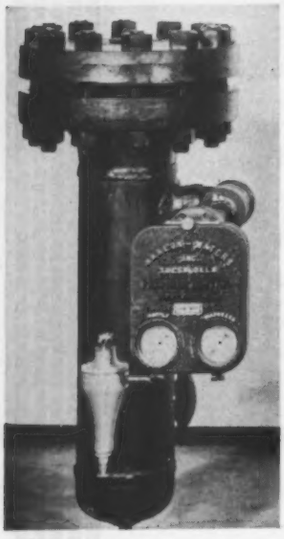
**THE PATTERSON FOUNDRY AND MACHINERY COMPANY**

A new line of gas absorbers, equipped with turbines designed to secure intimate contact in breaking up the solution, has been announced by The Patterson Foundry & Machine Company, East Liverpool, Ohio. They are available in a wide range of size, and are built of plain and stainless steel as well as of a variety of non-ferrous metals.



**Patterson Gas Absorber**


CONTROL ★ LIQUIDS
OF ANY GRAVITY, TEMPERATURE
OR WORKING PRESSURE



WITH Hanlon-Waters Type 850 LEVEL CONTROLLER

★ Ask the Men Who OPERATE THEM
They are our Best Salesmen

THE ONLY LEVEL CONTROLLER WITH
NO STUFFING BOX . . . . . LEAKAGE . . . . . FRICTION

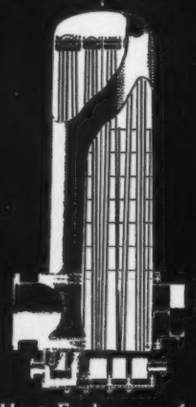
H-W TYPE 850 IS SATISFACTORILY HANDLING PROBLEMS THAT WERE CONSIDERED IMPOSSIBLE

*Complete information and prices available at your nearest HANLON-WATERS Branch.*

HANLON-WATERS, INC.
TULSA, OKLAHOMA
Chicago, Pittsburgh, Philadelphia, St. Louis, Denver; Shreveport and Lafayette, La.; Fort Worth, Houston, Corpus Christi, Longview and Odessa, Texas.



LEACH
FRACTO
CONDENSERS
for High Pressure
and Temperature.



Also Heat Exchangers for Vacuum and Atmospheric Service.

Fracto Control

Patented in the United States and Foreign Countries.

C. H. LEACH CO., Inc.
117 Liberty Street, New York, N. Y.